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THE

PHYSIOLOGY AND HYGIENE

OF THE

HOUSE IN WHICH WE LIVE.

BY

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"Know ye not that ye are the temple of God, and that the Spirit of God dwelleth in you? If any man defile the temple of God, him shall God destroy; for the temple of God is holy, which temple ye are."

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PREFACE.

THE body, in this book, has been likened, in its various parts, to a house, and it may be truthfully claimed that no other of man's dwellings has as many "modern conveniences" as his body. There is nothing that his ingenuity has yet devised for the safety and comfort of his home that he may not find foreshadowed, and usually bettered, in the body. Where, for instance, can you find an automatic steam or hot-water heater that will perform its work as well as the thermogenetic system of the body? Where can the block or building be found that is as well sewered and ventilated? Furthermore, he finds in this house of ours elevators, telegraphs, and telephones innumerable, also pictures, photographs, library and music-rooms, and a dining-room from twenty to thirty feet long. But the best of all are the hosts of trained and uncomplaining servants that go with the premises; porters, cooks, waiters, messengers, photographers, carpenters and joiners, are all found on the estate, and ready to work without other wages than food and lodgings for their life-time, and they never leave the property on any pretext whatever.

Moreover, this house of ours is portable, and can be moved whenever we please; and, what is more remarkable, this house of clay, as the theologians call it, can be

rented for a term of years under the most reasonable conditions. All the Landlord asks in return is that the premises should be kept in good repair. Surely the terms are not hard, not difficult to comply with; but, light and easy as they are, the penalties attached to non-fulfillment are heavy. Health is prompt and cheerful compliance with the terms upon which we hold our bodies. Disease is our witting or unwitting breaking of them. Hence the absurdity of the question, "Why is not health catching instead of disease?" Disease never occurs until the laws of health have been broken somewhere—either by "this man, or his father," by violation of personal or public hygiene. This little book is designed to aid, as far as possible, its readers to keep these laws, and in so far as it accomplishes this, its purpose has been fulfilled.

M. P. HATFIELD.

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PHYSIOLOGY AND HYGIENE.

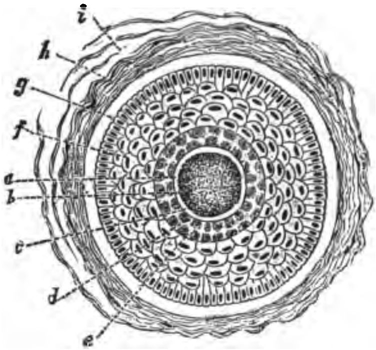
CHAPTER I.

MOSAICS AND TAPESTRIES.

THERE are at Rome four marvelous mosaics. Viewed from the pavement beneath they appear like exquisite life-size paintings representing the four evangelists, but with a nearer approach they become gigantic in their proportions, and it is found that their wealth of color and beauty of form are due to bits of colored glass and stone, so skillfully arranged that at a distance they produce all the effect of an oil-painting.

So it is with the human body when studied beneath a microscope. All the beauties of color and form of this earthly habitation are there found to be due to a marvelous mosaic of cells whose workmanship is more exquisite than that of any Roman or Florentine workman. Even an ordinary hand-glass will reveal the ragged edges and rough joinings of these pictures in stone, but the finest microscope fails to show any imperfection in the finish of the mosaic of cells found in the body. Take for instance the cross section of a single human hair and the sac in which it is held. In what king's palace can a more beautiful piece of mosaic be found than this? German patience, like divine wisdom, has recently taken the time to number the hairs of our heads, and finds that a red head has 90,000 of these mosaics, a black 108,000, and two brown ones 109,000 and 140,000

respectively, and each one finished with a dainty care imperfectly shown in the cut. No wonder Paul declares that a woman's hair is her glory. What would he have said could he have looked through the modern microscope, which reveals thousands of wonders never dreamed of without its aid? And yet we take weary journeys to far-off Rome and Naples to see Pompeian mosaics without a tithe of the beauty of those we carry about with us daily.



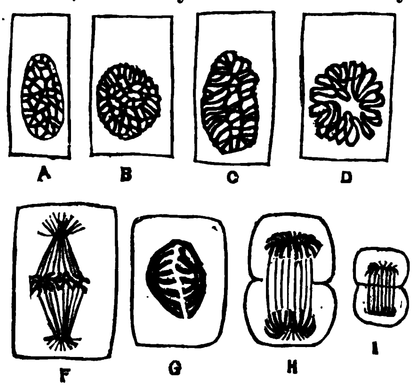
Cross section of human hair follicle, showing outer fibrous coat, basement membrane, outer root sheath, polyhedral cells, inner root sheath, and hair itself.

Nor are the tissues, or tapestries of the body less wonderful than those of the Gobelin factory, which cannot produce such a sack as the human *integument*, or skin. Such another bag was never elsewhere woven, for its fabrics are so delicate that they need to be kept covered with fine powder lest they should be injured. Histologists call this powder dried epithelial scales, and with these the whole surface of the body is dusted in layers of various thickness, always deepest where there is the greatest pressure. Hence, on the soles of the feet and the palms of the hands the outer layers of the skin become thick and horny; but epithelial scales are found every-where else as well, completely covering the surface of the true skin, which lies beneath, and is thus protected by these fine white scales, softer than snow and serving a not dissimilar use. Take the blade of a penknife and gently scrape the back of the hand, and in a few seconds these scales may be found as a fine white dust on the knife blade. So light and impalpable is this epithelial powder that a breath carries it away, and fortunately so, for otherwise we should grow as thick-skinned as a rhinoceros. Layer after layer of these

dried scales are continually falling from the surface of the body in larger numbers than the dead leaves of an autumn forest, so that epithelial scales can be found every-where that dust gathers, "from the tops of the highest mountains to the innermost recesses of the pyramids." And whence comes this never-ending supply of fine, branny scales? They are pushed up from below by an incessant growth of new integument, or skin, which shoulders away the parent cells which produced it, and thrusts them out to die of exposure, like a pious Hindoo on the banks of the Ganges. Integument consists therefore of two kinds of matter: loose white scales on the surface of the body and the rounder, moister ones beneath; the former are dying or dead, and the latter are alive, and possess germinal matter.

Germinal matter, so named by Dr. Lionel Beale, is perhaps the most marvelous thing in all the human body. It is, in a certain sense, its builder; for there is a time when the body begins its existence as a transparent mass in which are imbedded granular points. These differ from the matter in which they are imbedded by the latter refusing to take a stain from a carmine solution, which readily tints germinal matter with its characteristic color. This germinal matter is almost as transparent as that by which it is surrounded, and, so far as can at present be ascertained, is perfectly structureless. It consists of minute points not larger than one fifty-thousandth of an inch in diameter, scattered or in groups, and always surrounded by larger or smaller quantities of so-called formed material (matrix). This formed material is supposed to be the product of germinal matter, and, unlike germinal matter, has no more vitality than any other organic compound. Like other organic matter, formed material is subjected to the usual laws of chemistry, and is oxidized and changed like similar material outside of the body; but germinal matter resists such agents, and as long as it lives possesses the property of being able to project one part of itself in advance of the remainder. In this way germinal matter may travel directly through any of the tis-

sues of the body, apparently using formed material for nutriment as it divides and subdivides. The chief work of germinal matter seems to be its division and subdivision; upon this the growth of the tissues depends, while cell walls and intermediate substance (formed material) become variously modified and form the various parts of the body, such as bone, cartilage, muscle, and integument. And thus it is the body grows, germinal matter breaking up into smaller portions, or nuclei, as they are called, each taking a spheroidal portion of formed material with it, and dividing and subdividing as growth requires, often after the most intricate fashion, weaving itself into graceful stars, loops, rosettes, wreaths, etc. (such as here figured), infinitesimally small, of course, for they can be seen only through a microscope.



Karyokinesis, or movements of cellular protoplasm.

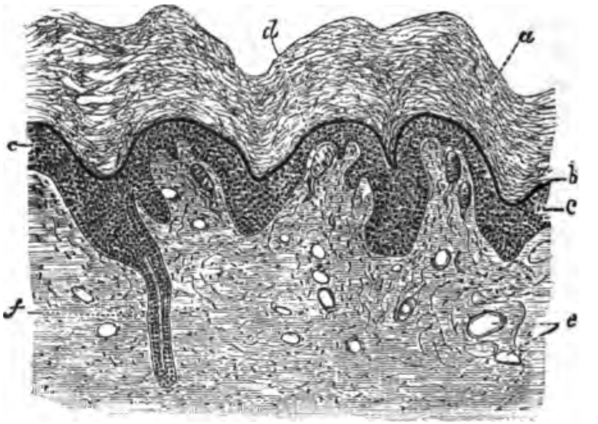
Upon these freaks of motion, for such they seem, depend the existence of the body; for these twistings and turnings of germinal matter precede its self-division, and upon its subdivison depends the multiplication of cells and all that it implies in the matter of growth and decay.

Germinal matter is the same thing as the protoplasm over which the scientists and theologians have often so unwisely fought. Protoplasm is not God, as some of the scientific men would have us believe, but, on the other hand, it as really exists as air, and is as capable of being shown in its wondrous work. Denying the existence of protoplasm, or whatever you may prefer to call it, does not abolish it. It may be used unfairly as a weapon against revealed religion, but too many such efforts have failed in the past, to give the Christian any uneasiness in re-

gard to the final outcome. Let him wait patiently, and he finds that his enemy's weapons become his best defense, as to-day one of the weightiest arguments against alcohol is framed from its effects upon this germinal or protoplasmic matter.

Strong alcohol dropped on heart muscles first paralyzes, then kills, this germinal matter. But, it may be said, only dilute alcohol is used for drinking, and this, when taken into the circulation, quickens the heart's action. Yes, temporarily, as it also makes us for a time think ourselves wiser and stronger than any one else. "O," says Dr. Holmes, "if the alcoholic virtues would only wash!" But, alas! they will not, for the poem, the book, the lecture delivered under alcoholic stimulus is never taken elsewhere at its valuation. The dynamometer is pitiless in its verdict, and that says absolutely that these servants of ours cannot lift, pull, or do any kind of work as well after as before the glass of whisky that makes one feel—that is exactly it: apparently, not really—stronger; for physiological experimentation proves that alcohol, in whatever form, diminishes the sensibility and lessens the contractility of germinal matter wherever it is found. Dip your fingers into alcohol, and after a little you will find them numb from the effect of the alcohol upon the germinal matter of the skin, for it is this germinal matter that perpetually renews the loose scales which make up the outer or *scarf skin*, which protects the sensitive nerves and tissues beneath. The necessity of such protection is shown whenever the scarf skin is removed, either by rubbing or blistering, and the sensitive true skin exposed to the air. This same is seen in a chapped skin, which is one from which the outer layer of epithelial scales has been removed by cold or irritating fluids, leaving the lower and softer layers to crack and bleed. This will be readily understood by a reference to the annexed cut, which represents the different layers of the skin on the tips of the fingers. The ends of the nerves and the blood-vessels of the skin are not well shown in the picture, which is simply designed to show the epidermis, or layer

of dried scales, basement membrane, and a soft layer of granular and germinal matter beneath, constituting the corium,



SECTION OF THE SKIN.

a. The epidermis. *b.* Two of the quadrangular papillary clumps composed of minute conical papillæ, such as are seen in the palm of the hand or the sole of the foot. *c.* Deep layer of the derma, the corium. *d.* Tactile corpuscle.

or true skin. Through the skin pass several miles of sweat glands, hereafter to be described; and in it are also imbedded the hairs, nails, and sebaceous glands.

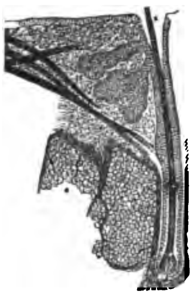
Hair is designed to form an elastic protection and adornment for the head. Minute hairs are, with few exceptions, also found every-where upon the surface of the body; but they are, if we are to believe the evolutionists, the useless heritage left us by our great grandfathers, the apes. A fine head of hair is a gift to be proud of, whether black, red, or gray; for the best art of man has never yet succeeded in making a satisfactory substitute, and it never will until it succeeds in making as exquisite a hair factory as that found in a hair follicle. A single hair is an insignificant thing, according to our way of thinking, but in the biblical sense of the statement our hairs are all numbered; for more care is shown in the arrangement of a single *hair* follicle than in an elab-

orate mosaic (page 10). First, we find a fibrous sac (*h*) lined with glassy membrane (*g*), inside of which are set the outer and inner root sheaths (*d. e. f*), most beautifully constructed of cells containing dark points of germinal or growing matter, and internal to this the cuticle of the hair (*c*), its cortex, or bark (*b*), and its marrow, or pith (*a*); for hairs possess marrow no less than bones. More properly, it resembles the pith of a feather, for it does not answer in any wise except in name to the marrow of the bones, which is largely fat. The fat of the hair is found in two little sacs, which serve a similar purpose to those found on a larger scale on the backs of water-fowl, located at the base of each hair (sebaceous glands). Man is in reality feathered, although Plato defined him as a "featherless biped;" but with better eyes he would have found that his definition was not scientifically correct, for a hair is essentially the same thing as a feather. They both have a central shaft, a pith, and a vane of barbs; but in the hair these encircle the shaft instead of being arranged laterally as on a quill. These barbs are proportionally smaller in the hair, but still they may be felt, even when they cannot be seen, as is readily proven by pulling a horse hair the wrong way between the fingers. The barbs or scales of a human hair overlie each other like shingles on a roof, and are unlike those of other animals. Microscopists are able, therefore, to tell with certainty from what animal a hair has been taken.*

A hair is prolonged at one end into a sharp, tapering point, and at the other it is expanded into a root, or bulb, as it is well named. Each hair bulb is set into a flask-shaped pocket

* In the late Piper case tried in Boston the guilt of the prisoner was established by a single human hair adhering to the inside of the prisoner's coat; and Gosse relates the following more remarkable case: "The knife of a prisoner on trial for murder was found to be stained with blood, which contained a single hair. The prisoner claimed that the knife had been used for killing pigs; but the microscope proved that the hair was not a pig's bristle, but a squirrel's hair; and as the little girl who had been murdered had worn at that time a squirrel boa, the chain of evidence was complete."

or depression in the skin, very much as children thrust twigs into soft clay, and the bottom of each pocket is lined with points of germinal matter, which reproduce the hair continually. Sometimes nature plays strange pranks in planting these bulbs, and instead of planting them in regular rows sets them round in circles, and then their unfortunate owner discovers, to his great annoyance, that he is the owner of a "cowlick," which requires all his patience and pomatum to keep in subjection. Fright and cold may also produce, on a small scale, temporary cowlicks; for attached to the base of each of these hair pockets are two miniature, involuntary muscles, by whose contraction some of the lower animals, as the horse and pig, erect their hair. In man these muscles are only influenced by cold or fright, which produces that condition of the skin known as "goose-skin," due to the contraction of these tiny muscles.



Longitudinal section through a human hair, showing hair follicle, papilla, and the muscle (musculus erector pili).

A hair, in its structure, is as delicate as the finest feather; and while it is exceedingly elastic, and perfectly adapted for the purpose for which it was designed, it cannot be frizzled and burnt and broken without destroying its beauty and its life. A hair curls for the same reason that a shaving does; namely, they are both flattened cylinders. The more nearly cylindrical a hair, the stiffer and straighter it becomes, as is seen in the Indian, while we find the opposite extreme in the negro, whose hair cylinders are so much flattened that they become kinky as wool despite the owner's efforts to the contrary.

The coloring matter of the hair is located in the pith, or central part, and its gloss is due largely to nature's pomatum pots, two of which are attached to the root of each hair, so that other dressing for the hair than a brisk brushing with a stiff brush is hardly ever required.

All other applications, unless it be a little water or vaseline, are untidy or injurious, except in cases of diseases of the

scalp, when a physician's advice should be taken instead of an "almanac's tonic." Patent hair dyes are especially to be shunned; for with very few exceptions they owe their value to lead salts, and these, sooner or later, produce poisoning and paralysis. No one in his senses was ever long deceived by dyed hair, although the attempt is as old as the time of the Pharaohs; but the Egyptians were wiser than we, for they shaved the obnoxious hair off from their heads and wore, instead, wigs dyed to order. Artificial hirsute abominations date back to Margaret of Navarre. "Margaret of Navarre," says history, "having through sickness lost her blonde locks, cut off similar ones from her plebeian subjects and wore them instead of her own." History repeats itself, and every town has its local Margarets, who borrow their coiffures or bleach their own locks by means of peroxide of hydrogen, and thereby permanently injure their hair. Gray hairs are a crown of glory, says an excellent authority. Moreover, as yet, no device has been found that will safely restore them to their original color. Early gray hairs and bald heads are part of the price that is paid for modern civilization; and the only way to defer the inevitable is to keep the head cool, occasionally washed free from dandruff with a little borax and water, and the hair thoroughly brushed with a stiff brush several times daily.

Dandruff is simply another name for the dead, epithelial scales found every-where on the surface of the body; but being confined to the head by the hair, they are apt to accumulate until they become a source of annoyance to the possessor. Unless it arises from a diseased scalp, dandruff may be readily removed by washing the head with a solution of borax or salts of tartar, either of which readily dissolves these scales, but requires that the scalp should be washed immediately after with pure warm water. Similar treatment will remove the coating on the tongue, observed in many disordered conditions of the system. It would be a Hibernicism to speak of this coating on the tongue as a dandruff of the mouth, but in reality both are due to a similar cause; namely,

excessive death of epithelial cells, which in consequence accumulate instead of being, as usual, swept away as fast as they die. In case of the tongue, the reason of this undue accumulation is congestion of the membrane lining the mouth, causing an increased growth of the cells on the surface of the tongue, which remain pasty and white or may become dried and colored by the disordered secretions of the mouth. The secretions of the mouth are as a rule diminished at such times, and hence are insufficient to remove the fur, which in protracted fevers continues to increase, unless removed, adding greatly to the discomfort of the sick. There is, however, no better reason for allowing this to remain in the mouth than dirt elsewhere upon the surface of the body. It can easily be removed by scraping with the sharp edge of a penknife; and the mouth of a fever patient should no more be allowed to become unclean than his face.

The relation of a furred tongue to *finger-nails* may not be apparent unless it be remembered that the nails, like the fur upon the tongue, are epithelial scales packed closely together. With proper treatment under a microscope they can be shown to be identical, with, however, this very great difference: the fur upon the tongue is dead and decaying matter, fit only to be thrown out of the body, while the nails, though hardly less vital, are admirably designed to protect and assist the ends of the fingers and the toes. A cutting of nail, even though it be not worshiped like that taken from the grand Lama of Thibet, is well worth our study. Examine a nail under a high power microscope and you will discover that it is made up of a multitude of little scales, so closely packed together, like figs in a box, that they are firm and solid and give the horny appearance to the nail. Beneath these we find softer, translucent cells (one fifteen-thousandth of an inch) which are continually growing and producing new nail at the root and the quick; that at the root pushing the nail forward and free from the end of the finger. The cells at the quick of the nail are so much larger than when they crowded together above that, to accommodate

them all, the bed of the nail is grooved or thrown into ridges into which the nail dove-tails, and thus, like a ship on the ways, is directed in the way in which it should go. As long as the bed of the nail is uninjured it will reproduce fresh nail, making an entire new one in four to six months; but if these ridges are destroyed a straight nail can never grow on that finger again, although nails have been known to appear on a second joint when the first has been removed.

A corn is an effort to form a nail, caused by the pressure of a boot upon one point of the soft tissues beneath. Pressure crowds the epithelial scales into a hard horny mass conical in shape. Its increase in size increases the pressure, and so on indefinitely until the pain becomes exquisite. Every motion of the foot seems to push upon that especial spot, not because that point is touched more frequently than usual, but simply because each touch becomes painfully apparent. Corns are the price we pay for improperly shaped boots; for a savage, having none, only acquires calloused, or generally thickened, soles. The pressure producing a corn is on one point, and as the result of this the corn constantly becomes worse unless it is removed by the chiropodist, and some method is devised to relieve the spot from pressure for the future. The proper shape for the sole of a shoe can be obtained by placing the stockinged foot upon a sheet of paper and tracing its outlines. Such a shoe may not be in the prevailing fashion, but it will accurately fit the foot and make walking a pleasure instead of a painful hobbling after the Chinese fashion. The feet deserve better care and more frequent attention than they usually get, especially in the way of nightly baths and well-fitting shoes.

Too frequent bathing is not desirable for the feeble in a northern climate; but a foot-bath, with mustard or salt if the circulation is poor, will do much to do away with cold feet, headache, and sleeplessness. Much of the general lack of enjoyment of health among well-to-do people comes from the clogging of the pores of the skin by an effort on its part to do the work of other organs. A shining, greasy, pasty-looking

skin means this, and requires a change in the mode of living—more fully to be discussed under secretion and excretion—or the complexion will be irretrievably ruined in spite of all powders and cosmetics. So dainty a piece of mosaic cannot be powdered, rouged, and white-leaded with impunity. The best cosmetics are a healthy liver, good food, fresh air, and frequent bathing of the face with soft water or that containing almond meal.

A broken skin fortunately mends itself, for germinal matter attends to that. If the general health of the body is well preserved there is a perpetual renewing, or relaying of the epithelial mosaic by these tiny, glassy points; moreover, when this is destroyed or injured, as by a cut or burn, in a very brief time these same tireless workers pour out a colorless glue which covers the wounded spot, and under which, unless the injury has been too great, a new layer forms. The most that the most expert surgeon can do in such cases is to imitate Ambroise Paré, who said of his work, "I salve and God heals." All that antiseptic or any other surgery can do is to prevent external causes hindering this healing process. How fibril is joined to fibril and nerve to nerve we do not as yet know; but it seems as if each sort of germinal matter reached out and joined itself to its own kind. At all events, somehow or other, unless irritated by the microscopic germs every-where floating in the air, this union takes place, and we have now what is known as a cicatrix, or *scar*, denser and firmer than the original tissue. It is, in fact, a seam put into the torn tapestries with a finer than human skill, but still a seam, and, like all seams, thicker and not so perfect as the original fabric. Still, it is vastly better than an unseemly rent, or an aching cut, and is the best that can be done under the circumstances. Now, if for any reason the germinal matter is unable to piece together the hole, there is left a running sore, which when of long standing is one of the most difficult things in the world to heal, for the reason that the germinal matter at its base devotes itself to manufacturing white corpuscles (pus) instead of plastic lymph. Germinal matter

like men may get into bad habits, and one of these is the secretion of pus, or matter, as we ordinarily call it, from a healing surface.

Cartilage and *connective tissue* next deserve our attention, for in them we find how germinal matter binds together the different parts of the body; and nowhere can we find daintier work than that done by germinal matter in fibro-cartilage, as it is called, or that gristly material which ties together certain of the bones of the body. We find (beneath the microscope) that this unsightly material has as exquisite a design and finish as the finest Florentine mosaic. Or perhaps it can be better likened to a pictured tapestry. In fact, its name expresses as much; for it is one of the tissues of the body, and a tissue is something woven. These tissues are well named; for they possess scarcely less beauty, and more utility, than the famous Gobelin hangings. The anatomists call these tapestries, or tissues, by various names, such as areolar, elastic, connective, etc., each of which has its peculiar excellence and beauty. The most widely used of these hangings is the areolar, connective tissue, so called because it is honey-combed with small openings, or areas, connecting with each other. This elastic packing fills every nook and cranny of the body, and encircles its every organ so completely that if in any way all else could be dissolved away, the connective tissue would still form a ghost-like model of the body complete in all its parts, and bearing about the same relation to a man that skeletonized leaves do to a green tree. Beautiful as such a body might be, it would be as useless as the "baseless fabric of a dream," for all practical purposes. A body composed entirely of connective tissue would be as unsatisfactory as one composed of twine; but, rightly joined and fitted to the other parts, connective tissue is as invaluable as cordage on shipboard, and it is as variously modified to meet its various requirements as is a ship's rigging.

Now this areolar, connective tissue, or that resembling honey-comb, is, like honey-comb, filled with fluid (serum). Like every thing else in the body, this tissue fluid—which

closely resembles the watery part of the blood — has its duty to perform; namely, to moisten the five hundred odd muscles and their sheaths, which otherwise would rasp themselves to pieces over each other or the bones to which they are attached. (The absence of this fluid, conjoined with wasting of the muscles, gives us the pitiable objects known as living skeletons, who make a scanty living by exhibiting themselves at dime museums. Excess of this fluid constitutes dropsy, a hardly less unfortunate condition.)

Again, this connective tissue is not unlike the coarse paper laid beneath our carpets, and between the siding of a house, in thin, elastic sheets, serving as protection and packing for the odd nooks and corners that need filling up for symmetry. Otherwise the "form divine" would be as angular as a Virginia rail fence. The structure of the body's sheet wadding (to use the name given by dressmakers to a substance similarly employed to help out Nature's deficiencies) varies according to the especial use to which it is to be put; but it is essentially a web of fine, wavy, white, inelastic fibers (one four-thousandth to one forty-thousandth of an inch in diameter), crossed by a greater or less number of coarser, yellow, elastic fibers, and according as the first or second of these predominates we have what is known as white fibrous or yellow elastic tissue. Where the first of these is used for muscle sheathing, it is called *fascia*, from the Latin word for bandage; and an excellent name it is, for it well expresses the care with which these bundles of muscles are swathed. We admire the ingenuity and the almost endless yards of bandaging employed by the Egyptians in preparing their mummies; but even greater care has been used in enveloping not only each limb, but every muscle as well, of the body. Each of these has its separate bandage or sheath, which differs somewhat as it is found near the surface of the body or deeper. The external or superficial fascia lie near the surface, and consist of moist, loose layers of connective tissue, while that which lies below is often woven into intricate layers.

Connective tissue, when long boiled, yields a transparent

substance known as gelatine, largely used in making artificial jelly. In addition the chemist finds in it a small percentage of inorganic salts and a large proportion of water; for connective tissue, like all the other soft parts of the body, is composed mainly of water. More than half (sixty-one per cent.) of the weight of a healthy body is due to the water which it contains, and when this is removed by drying, or age, the skin naturally shrinks and wrinkles. Wrinkles are inevitable with age; but it is entirely within our power to decide whether they shall be lines of content and happiness or moroseness, for wrinkling takes place in line of the greatest wasting of the facial muscles. Hence, one preserver of the form divine proposes to obviate this by washing and rubbing the face up instead of down as is usually practiced. Possibly this and chewing chamois leather, as is also proposed by the same artist, may put off the evil day; but a second fountain of youth would be required to prevent the wasting of fatty tissue, which sooner or later comes with advancing age.

Germinal matter, like every thing else, at last loses its vitality. In early life, so long as protoplasm is supplied with proper food, there seems to be hardly any limit to its powers of multiplication. During all these years the body constantly increases in height and weight. Then there comes a period when germinal matter just suffices to supply the waste of the body. These are the years in which the debtor and creditor accounts of the body in composition and decomposition exactly balance each other, or the sum of all the weights of the substances leaving the body exactly equal the weight of all the ingesta, or substances, including air, taken into the body. At last there comes a time when germinal matter is unable to fully repair the losses of the body, and then follow laxity of fiber, watery blood, and pallor of the face. "We all do fade as a leaf," and from exactly the same cause—namely, failing protoplasmic activity; which finally by the wisdom of its Creator brings us to the time "when the keepers of the house shall tremble, and the

strong men shall bow themselves, and the grinders cease because they are few, and those that look out of the windows be darkened, and the doors shall be shut in the streets, when the sound of the grinding is low. . . . and the almond tree shall flourish, and the grasshopper shall be a burden, and desire shall fail: because man goeth to his long home. . . . Then shall the dust return to the earth as it was: and the spirit shall return unto God who gave it."

RAMESES II. OF EGYPT.

The only apparent exemption from the flat, "dust to dust," is found in the case of the Egyptian mummies, which have been preserved by the care of their embalmers for thousands of years. The most interesting of all these is the mummy of Rameses II., recently discovered, and identified by Professor Maspero, by its inscriptions, as the Pharaoh who oppressed the Israelites and made their lives bitter with hard bondage in mortar and in brick. The body is that of an old man, for Rameses "must have been nearly a hundred years old when he died, but even under the somewhat grotesque disguise of mummification there is plainly to be seen an air of sovereign majesty, of resolve and pride."—*Maspero.*

CHAPTER II.

BEAMS, RAFTERS, CUSHIONS, AND SERVANTS.

SYDNEY SMITH wished in hot weather to take off his flesh and skin and let the breezes blow through his bare bones, but he was a good physician as well as a witty clergyman, so that a skeleton had for him none of the horrors that it has for those unused to its sight. It ought to call to mind no thoughts of "some charnel-house o'er-covered quite with dead men's rattling bones," but rather wonder and admiration for the divine skill which so wisely planned the beams and rafters of the house in which we live. A skeleton literally means something dry, and such it appears to the majority of students of anatomy and histology, but there is much to be learned and remembered from even an old bone. There may cluster about old bones some of our happiest recollections: Bible stories of the bones of the patriarchs; of Joseph's bones, carried by the children of Israel during all their forty years of wandering; of the jawbone with which Samson smote the Philistines; Elisha's bones, and the dead man; of Tamerlane's famous pile of skulls; the bones of the eleven thousand virgins at Cologne, and many more. Geologically they have taught us all we know concerning the strange monsters, the Megalosaurus, Dinotherium, Cheirotherium, Pliosaurus, and Pterodactyl. Of these we have but some bits of broken bones left, but from them the geologist has conjured up weirder monsters and stranger scenes than ever came from opium or hasheesh. Or, if you are mathematically inclined, there lies before you a whole calculus of possible problems respecting the mechanics and building together of these two hundred and forty timbers all fitly joined together by the Master-builder. Like the rest of his work, it

is well done and without haste, for it takes nearly thirty-five years to complete all of the bones of the body. If Flourens's rule is correct, that one fifth of an animal's life is occupied in the ossification of its cartilages, we ought to live at least one hundred and fifty years, but as a rule man rarely attains to the Psalmist's threescore and ten. Statistics on this subject have only been recently kept, but there is nevertheless a gratifying increase in the average life-time of man. In the sixteenth century the average longevity at Geneva was only 21.2 years. In 1603 the English government found it could profitably sell life annuities based on an average expectation of life of 26.5 years only. Ninety-seven years later, they were obliged to raise this to 33.9 years to avoid loss, and again in 1871 this was again increased to 41, so that for Englishmen at least the span of life is lengthening. In fact, many if not most of their prominent men are still hard at work at an age that a century ago would have been expected to have laid them in retirement, if not actually in their graves.

Bancroft, Bismarck, Gladstone, De Lesseps, N. S. Davis, are all in years, past what was once supposed to be the age of efficient work, yet each of them stands to-day easily at the head of his particular line of work. John Quincy Adams, Benjamin Franklin, Brougham, Disraeli and Palmerston are all instances that a man's efficiency need not be measured by his years, for all of these did their best work when past seventy. Worry, fret and debt do more to age men than intellectual work. We hear much of youthful genius, but a careful analysis, by the late Dr. Beard, of the life-work of the thousand men who have been the leaders in the world's thought and activity shows that their greatest efficiency has been between forty and fifty, or, as Dr. Beard puts it, "the bronze age for man is between twenty and thirty, his golden from forty to fifty, his iron from fifty to sixty; but if a man in good health would forget his age he will be likely to run far over his seventieth year before he finds his mind or body burdened with years." More men fret out or rust out than wear out, and the surest way to

reach ninety years is to find engrossing work which keeps at exercise every faculty of mind and body. "A man may be old at forty, or he may be young at seventy, and there seems to be no surer way of growing old than determining at some set time to quit the active employment to which he has long been accustomed."

"Nevertheless, from the elaborate tables drawn up by Dr. Farr it would seem there are certain very critical periods in life. A baby, for instance, has but one chance in five of growing up. The period between the tenth and the fifteenth years, exclusively, is that in which the death average is the smallest. At about thirty-five we must begin to take care of ourselves. At this period constitutional changes set in; our hair and teeth begin to fail us; our digestion is no longer what it used to be; we lose the vigor of youth and neglect out-door exercise; above all, the cares of life begin to make themselves perceptibly felt. It is at this time that deaths from suicide take a marked place in the returns of mortality, and there is also considerable reason to believe that habits of intemperance are apt to suddenly develop themselves. It appears, moreover, that if a man tides over his fiftieth year he may make tolerably certain of living to seventy, while if he reaches his seventy-fifth year there is very strong presumption that he will either turn his ninetieth birthday or very near it."

The growth of the human body, like that of a tree, is not the same for all seasons of the year, being greatest in growing children in June, July, and August, as proven by the careful examinations of the children in the Danish deaf and dumb institutes.

"Each child was weighed four times a day—in the morning, before dinner, after dinner, and in the evening; and was measured once. These daily records show that, contrary to general opinion, the increase in weight and height of the human body during the years of growth does not progress evenly throughout the year. Three distinct periods were observed, and smaller variations were noticeable within these

divisions. In bulk, the period of maximum increase extends from August to December. A period of equipoise then succeeds until the middle of April, and the following minimum period completes the year. The lasting increase in weight occurs during the first period; the period of equipoise adds about one fourth of that increase, but this is almost entirely spent during the last period.

"The increase in height shows a similar division into periods, but in a reverse order. In September and October a child grows only a fifth of what it did in June and July. Thus in the autumn and early winter a child increases in weight, while the height remains stationary. In the early summer, on the contrary, the weight changes but little, while the vital force and nourishment are directed toward an increase in height."

There also is a fixed relation between weight and height, as proved by Dr. John Hutchinson, who collected the height and weight of upward of five thousand persons. The following table, according to his calculation, shows the relation which should exist between height and weight in a healthy person. A man measuring

5 feet 1 inch	should weigh	120	pounds.
5 feet 2 inches	"	125	"
5 feet 3 inches	"	133	"
5 feet 4 inches	"	139	"
5 feet 5 inches	"	142	"
5 feet 6 inches	"	145	"
5 feet 7 inches	"	148	"
5 feet 8 inches	"	155	"
5 feet 9 inches	"	162	"
5 feet 10 inches	"	169	"
5 feet 11 inches	"	174	"
6 feet	"	178	"

Or we may very much simplify Dr. Hutchinson's table, and say that, as a rule, a man's weight increases at the rate of five pounds for every inch of height, and this rule holds good for all practical purposes.

Upon the average, boys at birth weigh a little more, and girls a little less, than six pounds and a half. For the first twelve years the two sexes continue nearly equal in weight, but beyond that time males acquire a decided preponderance. Thus, young men of twenty average about 143 pounds each, while the young women of twenty average 120 pounds. Men reach their heaviest bulk at about thirty-five, when they average about 152 pounds; but women slowly increase in weight until fifty, when their average is about 128 pounds. Taking men and women together, their weight at full growth averages about twenty times as heavy as they were on the first day of their existence. Men range from 108 to 220 pounds, and women from 88 to 207 pounds. The actual weight of human nature, taking the averages of ages and conditions—nobles, clergy, tinkers, tailors, maidens, boys, girls, and babies, all included—is very nearly 100 pounds. These figures are given in avoirdupois weight; but the advocates of the superiority of women might make a nice point by introducing the rule that women be weighed by troy weight—like other jewels—and men by avoirdupois. The figures will then stand: young men of twenty, 143 pounds each; young women of twenty, about 146 pounds each.

According to Huxley, "The normal man's weight is 154 pounds, namely: Muscles and their appurtenances, 68 pounds; skeleton, 24 pounds; skin, 10½ pounds; fat, 28 pounds; brain, 3 pounds; thoracic viscera, 3½ pounds; abdominal viscera, 10 pounds, and blood which would drain from the body, 7 pounds. The heart of such a man should beat 75 times a minute, and he should breathe 15 times in the same space. In 24 hours he would vitiate 1,750 cubic feet of air to the extent of one per cent. He would throw off by the skin 18 ounces of water, 300 grains of solid matter, and 400 grains of carbonic acid gas daily; and his total loss for the same time ought to be 6 pounds of water and a little more than 2 pounds of other matter."

Each bone of the skeleton is securely wrapped in perios-

teum which looks very much like a dense sheet of bluish-white rubber, in which are safely packed the blood-vessels which nourish the bone. As it is peeled off from the bone it is dotted all over its lower surface with red points, which are the bleeding ends of these minute vessels which were torn into as the periosteum was stripped off.

Bone that has been thus treated dies. And why? Because when its periosteum is taken away you take away its nourishment, and there is nothing left for the bone except starvation, and to have its corpse pushed out of your body—very likely killing you in the operation; for nature's method for the removal of dead bone is exceedingly slow and exhausting; hence the surgeon takes great pains to open as early as possible a felon, lest the matter imprisoned beneath the periosteum cause the death of the bone. Furthermore, it has been found that the periosteum not only furnishes the bone food and clothes at once, but, when required, a glue also, better than Hilton's Insoluble or Spalding's Patent. If you snap a bone, it is the periosteum that helps to glue it together again, and after it is thus glued the bone is stronger just there than before it was broken. There are, however, several practical objections to strengthening bones in this way, the chief of which is that the bone is very apt to be shorter after the operation, even though the best of doctors has had his fingers in its setting; so that, on the whole, it is better to have weaker bones than to limp. Periosteum ends just before it comes to the joints, and for good reason this is so. In the joint we do not want two rough, elastic substances, full of blood-vessels, grinding against each other every time the joint is moved; so here we find periosteum replaced by what is known as joint cartilage. This somewhat resembles periosteum in its general appearance, but is thinner, without blood-vessels, and as smooth as ice. But even these polished surfaces would grow rough, as a creaky hinge does, if they were not kept oiled, so to speak. Perhaps moistened would be a better word, for the surfaces of the large joints are constantly kept slippery with a substance very like the white

of an egg; in fact, that is just what its name, *synovia* (from the Greek), means. The joints are kept in running order by means of a broad band which surrounds the joint from periosteum to periosteum, from which it gets a plentiful supply of blood; and this fine fringe is kept dripping with synovia, and the blood-vessels are thus kept out of harm's way. The *cartilages* are a large, useful, and important part of the body. They are all elastic, tough, and flexible—in a word, "rubbery" would describe their family characteristics. And so, knowing what these are, it may be easily surmised where you will meet with cartilage; for in this house of ours we find the materials are put just where their qualities are most needed. For instance, have you a nose that is fated every now and then to get a most unwelcome blow? A solid bone nose could have been made more ornamental, but it would certainly have been cracked or knocked off every time we fell on our faces. Nature knew very well what she was about when she made the lower end of the nose of cartilage, so that we have, as it were, a rubber nose tacked on the end of a Socratic bone one; and now this nose of ours can be bent and tweaked and banged to a considerable degree without injury.

Some one thinks he has discovered that all noses are bent to one side or the other, according as we are right or left-handed. This man must be a Yankee; for, arguing that if the continued use of a soft handkerchief can so twist the nose why should not an iron instrument do so still more, he therefore has invented an instrument to correct unhandsome noses. Every one, therefore, who has a nose "like flower atilt"—which is the Tennysonian for pug—or crooked nose, or flat, and would have an aquiline, etc., may purchase one of this man's machines and have his nose grow into the desired shape, provided he is willing to wear one of the machines daily as long as it can be endured. A long nose is said to denote, power, merit, and ability; a straight nose justice, seriousness, and energy; a Roman nose a propensity for adventure. A cleft nose is a mark of benevolence; a wide one,

with an open nostril, of sensuality; a curved fleshy nose of domination and cruelty, and the curved thin nose accompanies a brilliant mind, but vain, and disposed to be ironical. At least so claims the author of *La Science en Famille*, but more likely our noses betoken the characters of our grandfathers than our own; if they have any value at all in that direction.

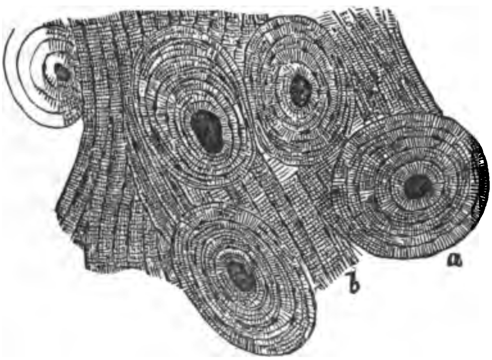
But to return to cartilages: some of which are bluish white, others are clear or glassy, while in another there are white or yellow fibers; but they are all cartilages.

Of all cartilages, "glassy" or hyaline is the most interesting. It might be well named "baby bone," for bones begin as cartilage. Strictly speaking, a baby has no bones, only soft, gristly cartilages; so that the blessed baby can give itself with safety many a bump that would put its grandmother to bed with broken bones. Nature quietly works away at these cartilages for twenty years and more, and if you will let her she will make a set of bones of which you may be proud. You must not work against her, nor hurry her, for during all this time your bones are more or less flexible, and will bend under continued pressure. For instance, a fond mother is very anxious that her baby should walk; his little limbs are not strong enough to support him, and very soon his knees bend out, his toes turn in, and a bow-legged son will be the price the mother must pay for her foolish ambition. The Chinese make hideous little dwarfs for beggars by putting their children, when about three or four years of age, into a large porcelain vase, from which they are only removed at night and returned at morning, until they break the jar by their size. The child's sufferings are as horrible as they are while forming the useless and hideous feet of the Chinese ladies, which are made by binding the heel of the foot while small against the ankle, so that the child practically stands on its toes. This is continued until the foot atrophies in this shape and the Chinese lady is left a tottering cripple, perched on the tops of her great toes. This is possible because the bones are first laid down as glassy car-

tilages which can be altered by pressure. Nature takes her time in changing this into bone. If the work were all done during the first few weeks of babyhood, we should live either as dwarfs, or with bones so small that they would be lost in the muscles. But Nature can afford to wait long enough to properly subdivide her work. For instance, she proportions out the sacrum, or lower part of the backbone into no less than thirty-five sections, and wisely, for as yet she does not know what we are to be, so leaves these provisional bits of cartilage to be transformed into such bones as required. The time comes when rubbery cartilage will no longer do us for bone, and having proportioned out the work it goes on somewhat as follows. The microscope shows us that those cells which are nearest the first point of ossification, or the spot selected for beginning the bone-making, begin to be disturbed, and their nuclei (germinal matter) have each an internal war which results in the cell splitting into halves, which crowd toward the first point. But these halves do not get there before they have another secession, and split again. And so these cells keep splitting, until that part of cartilage which is selected for making true bone is packed full of these split cells. The minute blood-vessels which have worked their way up among these cells begin to protect themselves by straining out through their walls a soft chalky substance, which fills up these cells every-where, except at the nuclei, which say, "thus far and no farther." Thus the original flexible cartilage becomes stiffened by the deposition of lime-salts about its points of germinal matter, or osteoblasts, as they are called in bone cartilage, until at last man possesses a perfectly formed bony skeleton, unless he has distorted it by carelessness or abuse.

The *skeleton* is essentially an irregular conical cage, with the lower part of its front gone, and at its bottom a shallow basin (the pelvis). Attached to the top of this cage is the neck and skull; to its sides the limbs, upper and lower, with their long bones, short bones, and irregular. The long bones consist of a hollow shaft whose ends broaden out into flat, articulating

surfaces, which contain within them what is known as latticed bone (cancellated), a sort of spongy bone which is found wherever large surfaces of bone and lightness are required at the same time. A cross section of this latticed bone looks as if it were composed of a multitude of tiny bone needles thrown together, like jack-straws, by the merest chance. But nothing has been done after that fashion in this house of ours, not even this apparently accidental net-work of bone needles, for, says Dr. Jeffries Wyman, an excellent authority on this subject, the fibers of cancellated bone are "so skillfully braced that they alone would be sufficient to prove that man naturally assumes an upright position." Standing upright is not as simple a thing as it seems. It would be quite impossible in a boneless body, or in one where the bones are softened, as they sometimes become in a rare disease, when the whole body becomes a helpless mass of powerless muscles. Even when not diseased the long bones would become twisted by the traction of the muscles attached to them, unless their ends were braced and strengthened in the way described. The shafts of the long bones are even stronger, for although in their structure they at first seem to have but little resemblance to lattice bone, yet under the microscope it can be shown that dense ivory-like bone (eburnated) and spongy latticed bone are really one and the same thing except in the relative compactness of their fibers; for it is only necessary to crowd those of spongy bone close enough together to convert the latticed



Bone section showing lamellæ and Haversian canals.

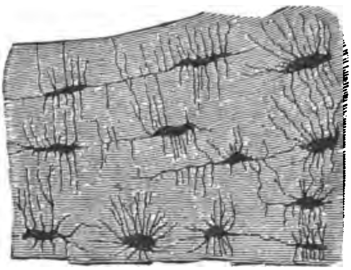
bone into the compactest kind of bone tissue, such as is found in the shafts of the long bones. Even the densest sort of bones show under the microscope minute openings (Haversian canals), into which the capillary or hair-like blood-vessels pass to nourish the bones. Around these are placed concentric circles (lamellæ) or layers of bone well shown in the previous cut. In fact, the microscopic appearance of bone may be compared to a bundle of lead-pencils, their interspaces corresponding to the lacunæ and canaliculi; for a higher power microscope shows, in addition to the Haversian canals, between the lamellæ (*a*) minute black lines (canaliculi), connecting irregular dark spots (lacunæ), looking not unlike crushed insects. These lakes and connecting canals, for such they are, constitute the lymphatic system of the bones, allowing from their great number the permeation of the entire bony system with nutrient lymph. Chinese ingenuity has never yet designed as intricate and efficient a system of irrigation as that which can be discovered in any old bone; for not only those of the human body, but the bones of all animals, are similarly provided. The openings in the bones of birds are longer and narrower than those of mammals, and the canaliculi remarkably tortuous. In the bones of fishes the lacunæ are long and narrow, and in reptiles angular and with few canaliculi. Hence it is that the geologist can tell from a sliver of fossil bone whether it formerly belonged to beast, bird, fish, or one of the huge lizards which once roamed this earth, for, curiously enough, the bones of an immense iguanadon and a tiny lizard of to-day have exactly the same markings.

Lacunæ and canaliculi are, so to speak, the water-marks which enable the expert microscopist to identify with certainty the variety of animal from which a given piece of bone has come.

Science plays sad havoc with many a tradition, and one of these thus rudely treated is that of the bones of the eleven thousand virgins at Cologne. The legend says they are those of Saint Ursula's maidens, but the anatomist looks at them through his microscope and unhesitatingly declares that they

are largely not human bones at all, but those of the lower animals, even chicken bones being found among them.

As has already been said, these bone-lakes and canals freely communicate with the lymphatic vessels of the marrow and those of the Haversian canals. The lakes, or spider-like lacunæ, are the original resting-places of the germinal matter (bone-cells), already described as being found in bone-making cartilage. These bone-cells, when recent, possess arms, or branches, which extend out into tiny canals communicating with it. As the bone-cells grow older these branches shrivel up and leave the canaliculi open for the transmission of lymph.



Section of bone showing canaliculi and lacunæ.

All of our bones are chemically alike in that they are composed of a gelatinous (organic) and an earthy (inorganic) part. In human bones, one third part is gelatinous and the remainder earthy. The organic part of bone is what gives it elasticity, while the earthy part is added to furnish requisite hardness and strength. The earthy salts can be entirely removed from a bone by soaking it in a dilute acid several days, which converts the hardest bone into a gristly, flexible substance, which is elastic enough to permit its being tied into a knot. This is the part of the bone which furnishes soup and jellies for the thrifty housewife, and is so permanent under favorable circumstances that Dean Buckland is said to have entertained a dinner party with a soup made from the bones of an extinct mastodon. To what base ends may we come at last!

"Imperial Cæsar, dead and turned to clay,
Might stop a hole to keep the cold away."

And less imperial we may have our poor skeletons boiled down to make glue, or ground to powder to convert their

earthy phosphates into fertilizers, for chemistry acts the ogre in *Jack the Giant-Killer*, whose threat to grind an Englishman's bones to make his bread is fulfilled in the modern fertilizer factory, where bones of every description are pulverized to scatter over the wheat-fields.

For convenience in study, the bones of the body are usually divided into four classes; namely, long bones, short bones, flat bones, and irregular bones, each admirably adapted for its special work; for example, the long bones of the arms and legs are levers designed for lifting and propelling the body. They are made hollow, for the reason that in this way is obtained the maximum amount of strength with the minimum quantity of material. Columns support weights directly in proportion to their diameter, and inversely to their height. Hence the heaviest bodies should have the shortest legs, and *vice versa*. As a rule we find this true. The balancing of the body upon the feet is no easy task, as every young child learns at the cost of many a hard bump. Standing is made the more difficult by the fact that the lower limbs, like the pig immortalized in nursery rhyme, are double-jointed—yes, and treble, for there are joints at the thighs, knees, and ankles. For running and jumping, this jointing of the leg is invaluable, but it adds greatly to the difficulty of keeping the body upright. This can only be done by the antagonizing of various groups of muscles, one set of which acting alone will pull the body over on the face; another will pull it on the back, others sideways; but when all of these muscles act together, the body is held upright, balanced exactly right. How difficult this is can easily be ascertained by trying to make a skeleton stand upright, or even a rigid corpse, as one frozen by cold. Walking, simple as it appears to us from constant practice, is even more difficult than standing. Learning to walk a tight rope, for an adult, is no more difficult a task than a child's first attempts at walking. No less than sixty-two bones are more or less necessary for the act, for the loss of any one of the bones of the legs or feet seriously cripples the process of

alternately falling and catching one's self just in time, which constitutes walking. To walk we must first stand, and standing requires that the center of gravity must fall inside of the feet, for which no less than eight sets of muscles are required to hold the body thus perpendicular in equilibrium. The slightest step disarranges this nice adjustment of antagonizing muscles, and the body would fall all in a heap if it were not that we have learned just when to catch ourselves before we fall, and in so doing we find ourselves a step in advance.

If we look at the process a little more in detail, we shall find that taking even a couple of steps is not a simple matter, for it requires, first, lifting the right foot the fraction of an inch from the floor; but even this little involves turning the body slightly on the left ankle, as a pivot, and balancing the body over the left foot. Now as the right foot is brought forward the body must be kept constantly bending forward, so as to keep it in equilibrium over the left foot, which is now the only pedestal. We cannot, however, keep on bending, for erelong we should fall on our faces; so just at the moment when the step would change into a fall—which only means the center of gravity gets outside of the supporting foot—down comes the toe of the right foot to the ground to act as a support. As the right foot goes down the left heel comes up, for the incipient fall was just bringing that left foot up from terra firma. For a second we are an equilateral triangle; but heel and toe are unsteady supports, so the body transfers its weight to the left foot entirely as the latter comes down squarely to the ground, and once more we are one-footed. As the left is brought to place, the body swings slightly to the right over the right ankle, back again until we are nearly upright, and now the left foot goes forward and the whole process is reversed. So that walking, simple as it seems, is really a most complex series of fallings, balancings, rolling from side to side, and alternately growing taller or shorter as we make ourselves into isosceles triangles or rectangles. It is a curious study, not only theoretically,

but practically; for, unlike many other things, the theory of walking is quite intricate, but the practice, provided you give your feet a fair chance, ought to be as easy as the swinging of a pendulum to and fro. Walking is capital exercise, but it is hard work as well; and when practiced on French heels, placed near the middle of the foot, is almost as difficult and tiresome as walking on stilts. The French heel is an anatomical abomination, and utterly useless for walking. The only shoe fit for this purpose is one with a broad, low heel and a thick sole broader than the foot. With such shoes, and with suitable clothing, walking is within the reach of every one's purse. Even a fashionable lady can profit much from her shopping if she will act upon the rule of using the elevator in going up-stairs and walking down; for walking up-stairs is hard work, and sometimes dangerous for those with damaged heart or lungs; going down-stairs hurts no one. "It shakes up the anatomy, without incurring the danger of physical overexertion. This shaking up is good for one's internal mechanism, which it accelerates, especially the liver, the kidneys, and the blood circulation."

Walking tied up in corsets is harder work than climbing up-stairs without them, for, as may be seen from the annexed cut, if the lower parts of the chest are allowed a chance for free expansion they afford ample space for breathing; but if tied down by a tight corset they have, as the Chinese say, "God's life" squeezed out of them. Of the two the Chinese small feet are the more sensible deformity, for they inflict no serious injury upon health. Argument, anatomy, and common sense combined seem powerless against Queen Elizabeth's girdle of buckram, the source of more female woes unnumbered than the wrath of Achilles. "It's the fashion to wear 'em," is the invariable answer to all objections urged against corsets, but why, if the corset, as is claimed, is worn for support, is not man better entitled to it than woman? We have it on good authority that Adam early in his existence lost a rib, and his boys may reasonably be supposed to have inher-

ited their father's deficiencies; although it is not true, as many Sunday-school children are taught to believe, that

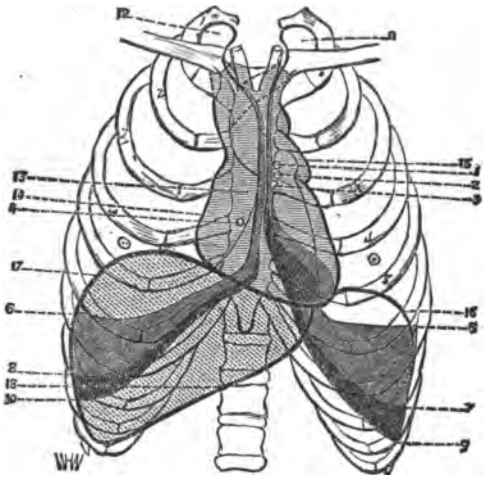


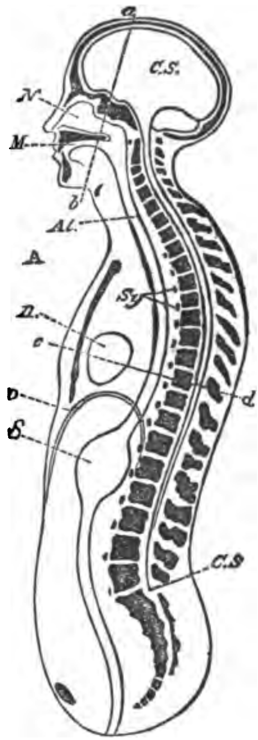
DIAGRAM OF THE RELATIONS OF THE THORACIC VISCERA TO THE WALLS OF THE CHEST. (BELLAMY.)

1. Situation of pulmonary orifice. 2. Left auriculo-ventricular orifice. 3. Orifice of aorta. 4. Right auriculo-ventricular orifice. 5. Limit of the anterior and inferior border of left lung in complete expiration. 6. Ditto of right lung. 7. Limit of left lung in inspiration. 8. Ditto of right lung in inspiration. 9. Limit of pleura. 10. Ditto. 11. Superior cul-de-sac of left lung. 12. Ditto of right lung. 13. Right auricle. 14. Right auricular appendage. 15. Left auricle. 16. Limit of diaphragm in complete expiration. 17. Ditto. ditto. 18. Ditto, ditto, in complete inspiration.

men are short one rib on the side from which Eve was taken. All have twelve ribs on each side—seven attached to the breast-bone and five free or floating ribs. These with the backbone, breast, and collar bones make the cage especially designed for protecting the lungs and vital parts within. Nature knew just how she wanted those parts protected; but fashion comes along and would remodel nature's work according to its own idea. But why should not a woman have as good a chance to breathe as a man?

A *backbone* is a most important thing for the body. This

"spine of the back," as Widow Bedott called it, has been the wonder of the anatomists of all ages. It might have been made a single straight bone; but oh! what a stiff-necked generation it would have left us. Infinite wisdom has fastened together thirty-three little bespangled bits of bone, called vertebræ, which are really a series of little levers, closely fitting one to another, firm, strong, and flexible, inclosing in their midst the spinal cord. The spinal column is really a spring with four curves, which break the force of every jump or sudden movement which otherwise would shake the soft brains to pulp against the bony skull. These curves in the back-bone are mainly due to little cushions of cartilage placed between the vertebræ. These cushions are called intervertebral disks, and are really bags of cartilage containing fluid, something as if each vertebra was guarded from shock by having a tiny water-pillow placed between it and its neighbor. A man is about a quarter of an inch shorter at night than in the morning. The reason for this is, that these little disks shrink by continued pressure of the day and expand after a night's rest. Continued unequal pressure may tilt the spine to one side or the other by the thickening or thinning of one side of these intervertebral disks, thus producing curvature of the spine; and one of the ways in which this is done is by the unlady-like trick of sitting upon one foot. It is too bony to make a



A, a diagrammatic section of the human body taken vertically through the median plane. *C.S.*, the cerebro-spinal nervous system; *N*, the cavity of the nose; *M*, that of the mouth; *Al. Al.*, the alimentary canal represented as a simple straight tube; *H*, the heart; *D*, the diaphragm; *Sy*, the sympathetic ganglia.—*Huxley*.

good cushion, and is responsible for not a few crooked spines, as may be seen by closely watching any large audience. There are rickety houses, and so there are rickety children, or those whose bones are so soft that the body is bent all out of shape. Later in life these twisted bones harden, as all bones do with advancing age, and the result is that the body becomes permanently twisted and deformed. Again, this may happen from increased fragility of the bones, which may be so great as to lead to fracture from the slightest violence. A slight degree of this is found in all old persons.

The boys on the streets call their heads "cocoa-nuts;" and this idea of the *skull* being a shell is as old as the early Danes, who called it "hierneskall" (brain shell). The skull is really an oval box made of eight bones, neatly dove-tailed together. This box shows in a beautiful manner the exquisite care that has been taken to guard from all harm what brains have been allotted us. Architects tell us that the arch of the skull—three arches, in fact, for the bones have each three layers—is so put together that it will resist the greatest amount of pressure with the smallest weight of materials; and it is wonderful how hard a blow can be received on the head without any serious injury following. Its cushions of hair and movable scalp add in no slight degree to the protection of the brain, so that it is rare that any ordinary blow brings us more than a bump; and if this bump is in the right place, according to phrenology, it will be a blessing. Science, however, has as yet only awarded to phrenology the Scotch verdict, "not proven." While it may be true that different functions are committed to different parts of the brain, and that one can often tell something of a man's character and way of living from the general shape of his head, yet it is in nowise proven that every fractional inch of protuberance betokens some corresponding faculty. In fact, we know that most of these skull markings go no deeper than the surface of the bone.

There is much that we could find to interest us in this brain cup, for it is full of markings made by vessels and membranes;

besides, there are passages many and various by which the nerves find exit, all showing the same watchful care. More attractive is the face, composed of fourteen of the crookedest bones in the body. In regard to its care it is scarcely necessary to say more than that it is not wise to attempt to retouch nature's painting. "Pearl Powder," said a philosopher, "is made of nothing but dirt, and rubbing such stuff upon the beautiful skin of a young lady is a dirty practice." The neck proper in all mammals, except two, consists of seven vertebræ, the upper of which is a pivot on which the head is hung, like that of a toy mandarin, whose head keeps bobbing with the slightest movement. And so would and does ours when we get too old to properly use our muscles; but ordinarily they keep the head accurately balanced on top of this pillar, on which it is hung on a swivel joint and a pair of rockers. In the neck are contained some of the most vital parts of the body. On the front of the neck are many large blood-vessels and the windpipe. When we look at their protection compared to that of the brain it seems very inadequate; but at approaching danger the head is instinctively drawn down, and these parts, thus protected, as are a turtle's when he withdraws into his shell.

The bones which would first attract your attention on the back are the scapulæ, or shoulder-blades, which are chiefly placed there for sockets for the arms. They have been frequently compared to sprouting wings, but our arms and not our shoulder-blades are our nearest approach to wings, and they are not a success in that line. Some one who had plenty of time has made a calculation proving that, even if a man had wings in like proportion to those of a bird, yet his body is so heavy that all the power which he could exert in a whole day would only suffice to hold him up in the air for five minutes. It is a discouraging prospect for all soaring Darius Greens, but they should console themselves with the thought that, though their wings are still rudimentary, their arms are far more wonderful. It takes thirty bones to form each of these instruments, which hang so lightly in the cups of the

shoulder-blades ; but all the patent offices in the world contain no model of any thing that could fill their places. The plan according to which our arms have been made is the same as that for all vertebrates; that is, we may say the arm is made up of five sections: (*a*) upper arm, (*b*) fore arm, (*c*) wrist, (*d*) palm, (*e*) finger; and the wing of a bird, the fore leg of a stag, and even the flipper of a whale are essentially arms.

If we went on all fours, probably we should walk on the palms of our hands, as do bears. As all arms may be considered to be made up of analogous five sections, you have only to count the joints to find that the stag runs on the tips of his first and second fingers, while the horse has only a stiff middle finger left on which to prance. So that while all vertebrates have in a certain sense arms, it is also true that their hoofs and paws are a very poor substitute for hands. Our Darwinian grandfathers come the nearest to having a human hand, but it has only a poor apology for a thumb.

As we pass down, we find the lower limbs, which hang droopingly from little hollows in that great dish of bone which, from resemblance to an old fashioned barber's basin, has been named the pelvis. This pelvis is a sort of a saddle in which we ride through the world, carried hither and thither by our trusty bearers, the legs. The cantle of this saddle is the "cuckoo-bone," which the learned Jewish rabbins declared was the indestructible part of the body. "Pound it," they said, "with heavy hammers on anvils, soak it for centuries in the strongest solvents, burn it for ages in the fiercest furnaces, it is all in vain—its magic structure will remain." To these wild imaginings Paul replied, "Thou fool, that which thou sowest is not quickened except it die," and to us the coccyx has become about as unimportant a bone as there is in the body.

Leaving then the bony system by the coccyx, or its extremity, let us turn our attention to our servants, the muscles, by which we are enabled to use our bony levers and joints. A muscle literally means a little mouse, but what the resemblance is

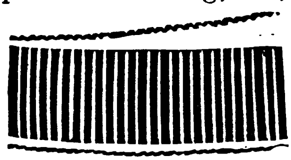
would be hard to tell, unless it was supposed that the contraction of a muscle resembled a mouse running beneath the skin. Generally, a muscle is thought of as a hideous compound of boiled beef and anatomical plates of skinned men; but a muscle is really more dainty and curious than a Swiss watch.

Turning over the plates of an anatomy, it seems hard to believe this, for they seem like the contents of that human butcher-shop over which we shuddered in the Arabian Nights. There are spread out before us long muscles and short muscles, flat and square, penniform and bipenniform, this one a bag, that one a ring; now as long as the tailor's muscle, and again like those of the ear, only a hair's breadth. They are a more motley company than Falstaff's own, and their names are worse. Some are named from their form; as the square muscle, the D shaped muscle, the two-headed, the three-headed, the saw muscle, etc.; others are named from their location, as the greater and lesser chest muscles, the temporal, etc. Again, they are named according to the ground they traverse, as the omo-hyoid, the chest, neck, and ear muscles; another anatomist decides that he will name them from the work they do, and we have consequently flexors, extensors, adductors, pronators, and supinators; and last of all comes some genius who has named them from some fancied resemblance or use, which last are the worst of all to remember. There are five hundred and twenty-seven muscles in all, two hundred and sixty-one in pairs, and five single ones.

There is one most important division of muscles which should be remembered; namely, voluntary and involuntary muscles, or those which act under the control of our will and those beyond it. It is a blessed thing for us that we have these involuntary muscles; for we must sometimes sleep, and the heart, lungs, and all the functions of animal life must be kept at work, or we should never see the morning. They are tireless, uncomplaining, patient workers. To be sure, the involuntary muscles do not directly write books, solve prob-

lems, paint pictures, build cathedrals, nor fire the Ephesian dome, but they keep the soul's home swept and garnished. It is a grand thing to do one's work well, no matter how humble it may be; indeed, we may find, in the last great day, that it is grander as the work grows humbler. So it may be that these despised muscles, which have "no sphere," are more to be admired than the haughtiest muscle that ever wagged the tongue.

All muscles are covered with a fascia, or bandage, of cellular tissue. If you have ever noticed corned beef, you must have seen how the muscle breaks up into bundles on boiling; and these bundles of fibers can be separated into separate fibers with careful dissection. If a microscope has not been used you have probably not observed it, but the fibers and bundles are each swathed in a bandage similar to that which holds the muscle itself. Now put one of these fibers under the microscope, and you will see that its covering is a transparent, elastic, membranous bag filled with a compact substance, which is striated or banded with alternate dark and light disks, through which are scattered cell nuclei, or germinal matter. In the voluntary muscles we find there is on the outside the fascia, which incloses in a common bandage bundles of fibers; then each bundle of fibers has its particular covering; and, lastly, we find each fiber is made up of contractible disks shut up in a common bandage. These ultimate voluntary, muscular fibers might be compared to a pile of black and white checkers shut up in a transparent, old-fashioned long purse. That comparison is, however, not quite exact, for we find by a higher power these disks are shown to be made of still smaller fibers running parallel to the sheath, as if the checkers were made of a fibrous wood.



Striped muscular fibers and sheath. —*Klein.*

The involuntary muscles differ from the voluntary in that they are not banded or striated, have no fibrillæ, and their

fibers have no covering, but are made up of long bands, each containing a rod-like bit of germinal matter. This is the last of the body to die, for Dr. Brown-Sequard, the French physiologist, has demonstrated that, for several days after death, during the rigid condition which immediately follow the cessation of life, the muscles of an animal undergo slow, alternate contractions and elongations; and he reaches the startling conclusion that the muscles in *rigor mortis* are not dead, but are still endowed with vital powers, being, however, in a certain chemical condition which is antecedent and preparatory to final death.

If the muscles did nothing but protect the vital parts and give form and beauty to the house in which we live, they might be compared to the bricks of an ordinary building, but they do far more than that. They both protect us and make us shapely, and are the "*sine qua nons* of all motion." Perhaps it would not be straining a simile to liken them to a company of waiting servants. Here they stand idle until the word comes telegraphed down the nerve, "Move this, or that." Take your forearm, for instance. You wish to bring your hand up to the body. The telegraphic office in the brain sends word to that group of servants we call the biceps muscle, "Bring up that forearm." No sooner is it received than each fiber recognizes the command, and, gathering itself together, pulls with might and main; and, as all the other fibers do the same, the whole muscle contracts or becomes shorter. Consequently, either the forearm must be raised or something will give way, as not infrequently happens in too violent exercise, when, for reason, the arm is restricted in its action, as in throwing a base-ball. The natural result of the contraction of the individual fibers of the muscles is either to drag the shoulder down to the arm, or the arm must come toward it or break. To prevent this breaking there is fortunately provided a hinge-joint at the elbow which allows the forearm to turn on it like a door on its hinges; so, instead of a crash, up comes the hand in much less time than it has taken to describe it.

The work of all the muscles is in its last analysis simply moving something, and in fact all the work done in this busy work-a-day world essentially consists of that. This something moved by the muscle may be either bone, muscle, cartilage, or ligament, but wherever a muscle is found there is a certainty that it has been placed where it is to do lifting of some kind or other by contraction of its muscular fibers. This contraction may come on involuntarily, and then it is said the muscle has a cramp, as many a boy has found to his cost when he has remained for too long a time in the cold water. The danger in such cases arises from the fact that a muscle thus involuntarily contracted loses its power of relaxing itself when we wish. A succession of these cramps, attended with unconsciousness, constitutes what is ordinarily known as a fit, or fits. There is hardly a more distressing sight that ever comes to the physician's notice than an attack of this description, where, apparently, every muscle in the body is convulsed and their hapless owner thrown hither and thither without power to control his motions. If consciousness is entirely lost we call such an attack a convulsion; if, however, consciousness is preserved, and an involuntary action of the muscles occurs, the disease is known as Saint Vitus's dance, from the saint who was supposed to have power over these gyrations.

The muscles are our servants, and better ones than most houses are blessed with. The servant question is one of the most perplexing of our modern civilization, but it is not one which vexes the house in which we live, for its servants differ widely from the ordinary domestic. These muscles of ours never insist on having every other afternoon and half day every Sunday. They have no innumerable flock of cousins to drop in at meal-time, they are never impudent, never take advantage of your necessities and give notice to quit because asked to perform a little unexpected work. On the contrary, they are willing and anxious to work, and ask in return only food, clothing, and training. The best of servants need this, and the muscles are no exception to the rule. Watch a baby

giving its muscles their first instruction, and see how greatly they need such teaching, for the first effort of a young babe to put its finger into his mouth often eventuates in damage to its eye; but in no other way than by practice can muscles be educated for their seventy or eighty years of service.

A curious as well as interesting series of experiments, made in France, shows approximately that the heaviest load a man of strength can carry for a short distance is 319 pounds; all a man can carry habitually, as, for example, a soldier his knapsack, walking on level ground, is 132 pounds—an extreme load, it would seem—or he can carry an aggregate of 1,518 pounds over 3,200 feet as a day's work, under like circumstances. If he ascend ladders or stairs, as do hod-carriers, then he can carry but 121 pounds continuously, and his day's work cannot exceed 1,232 pounds raised 3,200 feet high. With regard to the effort and the velocity which a man can produce by pulling or pushing with his arms, it has been found by these experiments that, under the most favorable circumstances, and for continuous work, an effect cannot be gained exceeding from 26.4 to 33 pounds raised from 1.8 to 2.1 feet per second, or about one eighth horse-power.

Climbing up stairs in all probability is a more difficult feat for a young child than the contortionist's feats for an adult, but once learned it becomes almost as easy as breathing. Herein is the value of education, for there is hardly any thing that these muscles cannot be taught if sufficient time is given to their education. Drawing, painting, music and sculpture all owe their possibility to the infinitesimal contractions of the tiny checkers of flesh figured on page 46. So varied are the accomplishments of well trained muscles that many claim there is a sixth, or a muscular, sense which enables man to walk, estimate weight, and do a score of things which require other aid than simple touch. Many of these wonderful feats are performed, by constant practice, at last almost automatically. This is largely true of the work of the musician, knitter, and telegrapher, for practice makes possible such difficult things that one is inclined to say that nothing is impossible to the really

determined man. Matching Scotch plaids by a blind man would seem to be very near a physical impossibility, and yet there is well authenticated proof of a canny blind tailor doing this so well as to become very successful in his business. Hardly less wonderful are the India ink drawings made with a brush held in the mouth of a helpless cripple of Boston. One of the famous French painters had no arms, and did all of his work with a brush held between his toes; and there was, until recently, if not at present, a member of the English Parliament without arms or legs, and yet this trunk of a man was so efficient that it was re-elected repeatedly to a seat in the House of Commons.

A willing servant may be overworked, and this sometimes occurs with the muscles, as happened frequently on some of the fearful marches of Napoleon's army, where the soldiers often would drop dead from sheer exhaustion. Such cases, however, are rare, for the protest of a jaded muscle is usually too emphatic to be disregarded, as can readily be tested by trying to hold the arm out horizontally for only ten minutes. If there has been no previous practice, it will prove the hardest bit of work you have attempted in many a day, for the complaint of the overtasked muscular fibers is so vehement that, unless there is a most determined will, long before the ten minutes are up the arm drops back to an easier posture. If, on the other hand, the protest is persistently disregarded, the muscle at length loses its power of contraction and relaxation, and it becomes impossible at last to move the rigid muscles. Thus the limbs of East Indian fakirs become at last permanently fixed when, in compliance with some vow, they are long enough held in a single position.

Simple inaction, then, may atrophy a muscle, or cause it to waste until it is unable to perform its duties. Just what the change is that takes place within the muscular sheath we cannot describe, but the fact remains that an unused muscle is a dying one. In the realm of the body, as in spiritual matters, the hath nots lose even that which they have, and physical and moral skeletons are the inevitable results.

Manual labor is irksome both from nature and habit, but the law of the house in which we live is that in no other way can its health be preserved. The contraction of each tiny fibril is absolutely necessary for its cleansing from effete material. Otherwise the House Beautiful grows dusty and filthy in the hidden corners, until its occupant is poisoned by his own fault. As we shall learn in the chapter on sewerage, these effete substances have been at last properly studied, but their headaches, lassitude, and general *malaise* have been known since the day when bounteous harvests and man's natural sloth first gave him the opportunity to take his ease to his own hurt. Exercise is as essential to good health as are sweeping and dusting to good housekeeping. Furthermore, inaction leads to a substitution of fat instead of muscle. A certain quantity of fat is needed both for protection and ornament. It rounds out the angles and arms of the English and German maidens and matrons in a way that makes them the envy of their less favored American sisters, of whom it might well be said, with Cæsar, "Would they were fatter." "Sleek-headed" men and women sleep well o' nights, for they have a good supply of extra adipose to meet the wear and tear incidental to modern life, which does not leave them at night nervous wrecks too utterly unstrung even to sleep. George I. thought a woman's beauty was in direct proportion to her avoirdupois, and gross as was his idea of beauty it was preferable to the school girl's "spirituel" ideal. Plumpness makes its owner warmer, happier, and generally better tempered than ninety pounds of flesh and bones, no matter how vivacious. So that so long as full weight (see tables for relation of height to weight) does not come from sloth, or gluttony, it should be regarded not as something to be dreaded and lamented over, but as a surplus fund upon which sickness and worry may draw in times of necessity. An undue amount of fat may be safely removed by the methods detailed in the appendix, but the cases in which this is required are rare in this country. Chalk, vinegar, pickles, and other school girl abominations are not to be

thought of, as they are both inefficient and dangerous. Properly arranged exercise and regulation of diet (see Chapter III) will do far more to reduce fat than any quack medicine. Such methods as are detailed in the Appendix should be adopted when the body becomes too well padded for comfort; but it should be remembered that a considerable quantity of fat is requisite for protection against cold, for a fat man does not dread a drop in the thermometer as does his thinner brother. And naturally so, for our fat friend has on an extra undergarment; or, if we return to the comparison of the body to a house, his is well sheathed, and bound with felt beneath its clapboards.

Fat is a poor conductor of heat; and hence an overheated person, if fat, cools slowly, and, *vice versa*, endures with comfort an amount of cold that is exceedingly irksome to one thinner. The arrangement of fat in the body is as daintily adjusted as if the despised substance was really an object of value, for fat is not spread over the internal surfaces of the body like butter upon bread; but each tiny roll of fat has its own envelope and cell. Under the microscope these fat cells appear like a spheroidal sac, containing an amber-colored fluid; for the fats of the body are held there in a liquid condition, since they melt at about the same heat as good butter. After death they cool, or as soon as the temperature of the body falls below normal. On the side of each sac can be found, according to some observers, a tiny point of Beale's germinal matter, whose duty is to elaborate fat from the fat-making foods. Others think fat comes from a churning of the fatty foods in the intestines, and that the butter, so to speak, is drained off and deposited in these cells, which may be found wherever areolar tissue—or that which is spongy and has numerous interstices—affords a suitable repository. No amount of starvation can ever remove all the fat from the body, for, no matter how emaciated the body becomes, fat may always be found behind the eye, around the heart, in the brain, and about the spinal cord. In short, it may be said that fat may be found normally every-where in the body

except between the air-cells of the lungs, in the lobes of the ears, and in the upper eyelids.

Beside normal fat there is what is known as pathological fat. Normal fat is designed to pad the body, and, like a camel's hump, to feed it in time of need; for many a plump body escapes at last, hollow-eyed and exhausted, from a tedious illness which it never would have survived if it had not been for the reserve-commissary department in its adipose tissue. The fat of disease is a vastly different thing, for it is not available fat, but fat that comes from the change of muscle into useless tissue. The pathologists call this fatty degeneration, and it is well named; for a muscle so changed has degenerated into a substance that is unable longer to properly perform its duties. If such change takes place in the muscles of the heart they may suddenly refuse to contract, and death inevitably result. More frequently they perform their work with increasing difficulty, making locomotion and work almost impossible, until the same result is obtained. If such fatty degeneration takes place in the walls of a blood-vessel they may suddenly rupture and the person die instantly of apoplexy, or be stricken with paralysis and drag along a precarious existence for a term of years. It is a well-known fact that malt liquors often enormously fatten those who freely imbibe them; but it should also be remembered that this fattening is largely of the pathological variety, for there is in these cases not only an abnormal deposition of fat from the superfluous hydrocarbons taken (see Digestion, Chapter IV), but there is also fatty degeneration of tissue, and consequent increased liability to death from heart disease and apoplexy. So well known is this that many life insurance companies refuse to take risks on the lives of those who work in breweries or largely use malt liquors. Cuts, wounds, and bruises upon such persons from similar reasons are very difficult to heal, and there is no one upon whom a surgeon more dreads to operate than one of these beer-bloated objects.

Beer, it should be remembered, cannot make muscles or

strength. It may and does benumb the faculties, and fatten; but this fattening is useless, and even harmful, unless it is one's ambition to transform his body into adipocere after death. Adipocere is the name given to an ammoniacal soap into which the fats of the body are sometimes converted after death. This is especially prone to happen in the case of fleshy bodies buried in moist ground and excluded from the atmosphere. Such bodies do not putrefy, but are slowly transmuted into a yellowish white, cheesy substance, unctuous and soapy to the touch. Such cases are rare, and certainly present no inducement to beer-drinking, even though these corpses are said to have been converted into a very fair variety of toilet soap by a sacrilegious Frenchman.

Moreover, it has been clearly shown, by actual experiment, that even a single glass of porter diminishes muscular contractility. A half pint of beer may make man feel as if he could lift a ton, but when placed on trial in the gymnasium it will be found that his lifting power is always less. Push it a little further, and the lifting power disappears entirely, for the man is poisoned—or intoxicated; for the words mean exactly the same. Muscles poisoned with alcohol are always paralyzed to a greater or less extent.

Paralysis is a loss of muscular power, either temporary or permanent. A temporary paralysis may be produced in any of the voluntary muscles by striking them sufficiently hard across their long diameter. Paralysis, however, usually occurs in a muscle from some trouble with the nervous apparatus, upon which it relies for the necessary directions for contraction. If for any reason the nerve wires become interfered with, the waiting muscle at the other end grows weary of the delay and, failing to get its fair share of the body's nutriment, like all other idle beings begins to waste away. Hence it is that a paralyzed limb is smaller than its sound mate; not because there is necessarily disease in the muscle, but because its disuse necessarily brings wasting. In a measure the same is true of every muscle disused from whatever cause. Hence the great need for systematic exer-

cise for all the muscles. An unused muscle is a starved muscle, and starvation inevitably brings emaciation. It is a stingy master who starves a willing servant, and no one was ever better served than we by our five hundred odd battalions of muscular disks; but they must, to perform efficient work, be well fed and cared for or they soon lose their cunning. The foods that are necessary to build up the muscles will be spoken of more in detail in a succeeding chapter; but it should be remembered that no amount of food can take the place of judicious exercise.

With our modern civilization and labor-saving machinery we find it necessary to resort to calisthenics, massage, and gymnastics to supply what is lacking in our way of living. All are excellent in place, and so greatly needed by the present generation that, by the aid of Dr. W. G. Anderson, an Appendix has been added to this book for the purpose of giving specific directions for the physical development of any part of the body that may be deficient. The needs of such systematic cultivation may be seen by looking over any miscellaneous audience in this country. Bright eyes, intelligent faces, and quick wit may be met with on every side; but a well-developed body can hardly be found. Almost every vocation dwarfs or disfigures the body in some way, so much so that a skillful surgeon can generally tell what a man's business is from the marks it leaves upon his body, unless he devotes some time daily to its symmetrical development. William Blaikie, in his *How to Get Strong*, claims that ten minutes a day, preferably either just before breakfast or at bed-time, is amply sufficient for this purpose; and the results obtained by Professors Maclaren and Anderson amply bear out this statement. No one is too busy to take that amount of time daily for the care of the body, and no investment of time pays better, in the hardest American sense; for, as has been well said by Herbert Spencer, the first requisite for (continued) success is that a man should be a good animal.

This is so often forgotten in our zeal for book knowledge that it will bear repetition. A dilapidated body is no more

a help to religion than any other dilapidated house to worship in, and we may be as much to blame for the body as the house. Muscles are tools ready prepared for use, and they must be employed or they rust. How they then damage the body will be further explained in the chapter on Moth, Rust, and Microbes. Such damage is as criminal as willful misuse of a friend's property, and as foolish as cutting shingles from one's own roof for kindling wood. Fine tools deserve fine care, and daintier tools than muscles never yet have been designed. Work is not the curse laid upon Adam, for before the fall he was set to dress and keep the garden. It is our unwillingness to work that constitutes its grievance. Our subterfuges to escape from it are but another instance of our folly; for the greater our success in this direction the greater our unhappiness.

We often learn much of the value of a substance from the care taken in its packing. From the great care that has been taken to wrap in sheathing each fiber and muscle it seems as if this held true of these patient servants of ours. First, each fiber has its own particular sheath (sarcolemma), in which the piles of disks are held as coins in a long purse; then these sheaths are bound together into larger bundles by a large sheath (perimysium), and lastly, the muscles are held together by a loose frame-work of areolar tissue and firmer fascia—bandages—for the word really means that. It has been well chosen, too, for no Egyptian mummy with its multitudinous yards of linen was ever bandaged more skillfully than is the human body with its many fascia, superficial and deep. See Chapter I. Fascia rolled in a hard white cord is usually called tendon or sinew, which are the strings by which muscles are fastened to the bones. The tendons are exceedingly tough, and will support a weight large in proportion to their size, but once ruptured they are slow to heal. Ligaments, except in name, are the same as tendons and are designed to hold the articular surfaces of bones together and thus prevent their dislocation or separation. Violent stretching of these ligaments gives rise to what are known

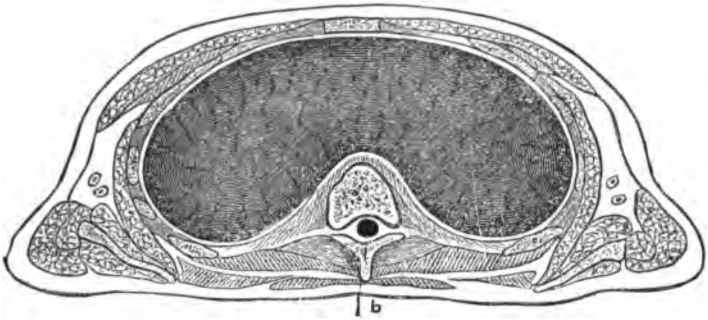
popularly as sprains, and which are often exceedingly slow to recover unless the joint is copiously bathed with hot water, and put as perfectly as possible at rest. Dislocations and fractures require the surgeon's aid.

To one interested in mechanics, a careful study of the joints of the body would well repay the time spent upon it, for there are found in the body hinge joints (elbow), ball and socket (hip), wedge joints, and most of the forms of mortice known to the carpenter. Probably no simpler or more efficient piece of joining was ever designed than the method adopted for binding together the bones of the fore-arm, which are so arranged that they allow both rotary and angular motion. This is done by making a hinge joint in the expanded end of one bone (ulna) at the elbow, and grooving the same so that the rounded head of the second (radius) rolls over it like a wheel, while at the wrist the expansion is reversed.

In fact, there is not a joint or a bone in the body which is not well worth more careful study than it is possible to give it in this chapter. Human and comparative osteology have taught us all that is known of the former inhabitants of this earth. Through all of them runs a general plan of structure and increasing perfection until we come to man, whom the Creator himself pronounced good. The ground-plan, so to speak, on which man and all animals are constructed is that of a double tube, and the lower the animal the more nearly equal and parallel are the tubes. In the anterior tube the lungs and abdominal organs are held, in the posterior the nervous system. These tubes, or cavities, in man differ widely in size, the anterior cavity, except in the head, where it holds the brain, being very much the larger, as is well shown in the cut on page 58.

The larger of these cavities is bisected by a partition or diaphragm, which divides it into two parts; namely, the thoracic and abdominal cavities. Each of these cavities has a separate entrance, both of which can be found in the mouth; that leading to the thoracic cavity being known as

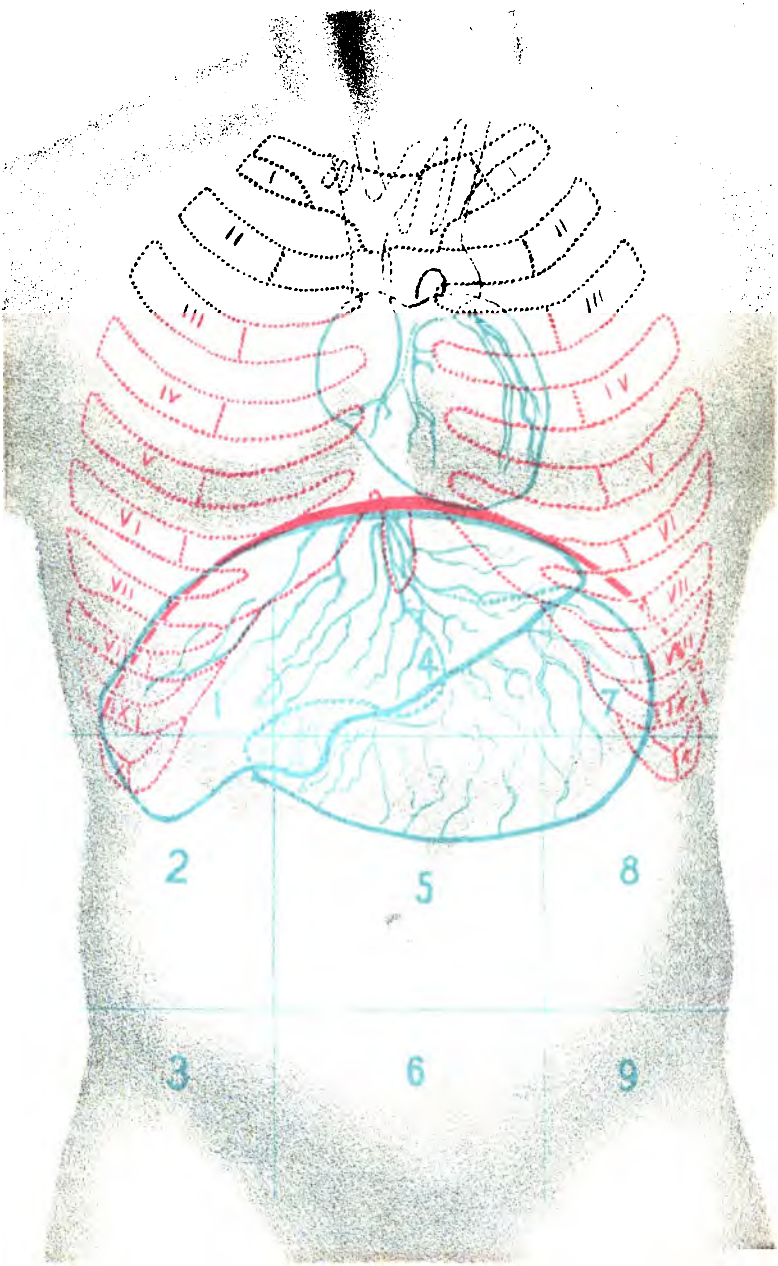
the windpipe, directly behind which can be found the tube (œsophagus), leading to the lower or abdominal cavity.



CROSS SECTION OF THORAX AT THE LEVEL OF THE SHOULDERS.
Anterior or thoracic cavity. *b.* Vertebral cavity.

The thoracic cavity, or chest, as it is usually called, lies entirely above the diaphragm, and contains the right and left lungs, and between them the heart and great vessels soon to be described. Their approximate situation may be fixed by remembering that a bullet would pierce the heart if it entered the chest at a right angle just above the fifth rib, and to the middle line just above the left nipple. A wound exactly in the middle line would involve both the heart and great vessels, and if to the right would escape the heart but pass through the right lung. A knife thrust into the lower intercostal spaces would wound the base of the lung during inspiration, but if done during expiration the lung itself might escape injury. See page 40.

The abdominal cavity, as its name indicates, is located in the abdomen. It is the largest cavity in the body, and entirely separated from the thorax by the diaphragm. Anatomists divide the abdomen by imaginary lines into nine regions, which are numbered in Plate I. The upper tier of these, namely, 1, 3, and 7, contain some of the most important of the abdominal viscera; namely, the liver, stomach, and spleen, all of which lie directly beneath the diaphragm. The spleen, concerning whose uses we have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much yet to learn, lies to the left of the stomach in region 7, and is an oval body, weighing four to eight ounces, well supplied with blood; but what it does there is yet a mystery to physiologists. In regard to the stomach and liver we are

LIVER, STOMACH, SPLEEN, AND BRANCHES OF CŒLIAC AXIS.

1. Liver. 2. Its transverse fissure. 3. Gall-bladder. 4. Stomach. 5. Esophagus. 6. Pylorus. 7. Duodenum, descending portion. 8. Transverse portion of the duodenum. 9. Pancreas. 10. Spleen. 11. Abdominal aorta. 12. Cœliac axis.

much better informed. The latter is the largest gland of the body, and will be more fully spoken of in Chapter V. The stomach lies between the spleen and liver, whose lobes partially cover the pyloric end of this irregular bag, which has two openings; namely, the cardiac, through which food passes from the œsophagus, and the pylorus (gateway), out of which the food passes when prepared for digestion. The stomach, therefore, is the kitchen of the body, and its duties and trials will be discussed in the following chapter.

CHAPTER III.

DINING-ROOM, COOKS, AND SCULLIONS.

THE kitchen is generally the least interesting place in a fine house, unless you expect to make it your home. Then it suddenly acquires a personal interest to the good housewife not to be exceeded by any room in the house. Its minutest appointments and deficiencies, if any, are well known and intelligently remedied as soon as possible. So it should be with the culinary department of the body, for we needs must eat twice or thrice daily, and our comfort more largely depends upon the kitchen than the parlor. Many of the processes below stairs are not appetizing to the looker-on, and the same may be said of digestion; but no lady is truly mistress of her house until she thoroughly understands what should be done in the kitchen. Similarly we need not keep constantly before our eyes the hideous charts of the digestive organs, which, perhaps more than all other causes, have made the study of physiology repulsive, but the why and wherefore of cooking and eating should be known to all. Ignorance on this point destroys more infant life than all the epidemics combined, and to one compelled to live with a confirmed dyspeptic it is usually a source of regret that indigestion later in life is not similarly fatal.

Dyspepsia is usually due to intemperance, not in alcoholic liquors alone, but in improper food, where temperance is as greatly needed as in regard to liquor. "Them religious," said a colored caterer, "eat awful." Saint Paul's injunction, "to knowledge, add temperance" was given not to the dissolute but to the Christian Church, which must obey it or suffer many wretched hours of gloom and dyspepsia. For intelligent temperance, knowledge is first requisite, and this

can only be obtained by a careful study of what changes are required in food to make it available for the uses of the body.

Food is whatever feeds the body, and hence in its widest sense it includes air and water, but as ordinarily understood will be used here as referring only to such foods as require digestion in the body.

Food ought to embrace all the elements found within the body, which chemists tell us are fifteen in number. These, according to Professor Atwater's table, exist there in the following amounts for a man weighing 148 pounds:

CONSTITUENTS OF THE BODY.

5 GASES	Oxygen	92.4	pounds.
	Hydrogen	14.6	"
	Nitrogen	4.6	"
	Chlorine	0.12	"
	Fluorine	0.02	"
3 METALLOIDS	Carbon	33.30	"
	Phosphorus	1.40	"
	Sulphur	0.24	"
7 METALS	Calcium	2.80	"
	Potassium	0.34	"
	Sodium	0.12	"
	Magnesium	0.04	"
	Iron	0.02	"
	Manganese	Traces.	
	Copper		

None of these elements except the gases, oxygen, hydrogen, and nitrogen, and these to only a limited amount, exist in a free or uncombined state in the body. The free oxygen found in the lungs and elsewhere comes chiefly from inspired air, whose function will be discussed in the chapter on Sewerage and Ventilation. Neither it nor free nitrogen or hydrogen is usually considered food, although in combination they constitute with carbon by far the most important part of all we eat.

Although the body is built up of the fifteen elements given above, it is as impossible to nourish it with them in their free or elementary condition as was the crazy Frenchman's scheme of creating a man by simply revolving in a vast

cylinder the exact quantity of each element found in a human body. He hoped by some happy chance that the exact number of atoms would arrange themselves just so as to construct a body if he could but keep them in revolution sufficiently long. That was many years ago, but as the new Adam has not yet appeared it is fair to conclude that the learned savant has failed in his experiment.

A similar attempt to feed a man on the amount of carbon, oxygen, and phosphorus excreted each day would be equally disappointing, for the chemical elements are not food, unless combined by chemical affinity. Chemical affinity, or chemism, is the force which holds elementary atoms together. Without this power in nature we should know but seventy substances instead of the infinite variety which we see on all sides.

If our present understanding of chemistry is correct, all of the infinite variety of substances known to man are combinations, more or less intricate, of about seventy original elements. By no means all of these combinations are fitted for food. In fact, but comparatively few are yet used, and these are not the simpler inorganic compounds, but more complex substances found either in the animal or vegetable kingdom. A body has to be built very much as a house, for no man takes so much free oxygen, so much carbon, and so much silicon to construct a brown-stone front, but utilizes the requisite carbon, silicon, etc., in the form of bricks, board, and stone, which are complex chemical compounds. So with our bodies, we should starve to death if we were fed on powdered carbon and gaseous oxygen, hydrogen, and nitrogen; but given the same substances in meat, bread, and butter, we laugh and grow fat.

Huxley estimated the amount of food required daily, thus: lean beefsteak, 5,000 grains; bread, 6,000 grains; milk, 7,000 grains; potatoes, 3,000 grains; butter, 600 grains; water about 6 pounds taken both as food and drink to supply the daily loss of the system. A large portion of the water required for the system comes from the food, as may be seen from the

annexed table of Professor Atwater, which shows that even what we consider solid food contains from fifty to eighty per cent. of water.

COMPOSITION OF ANIMAL FOODS.

FLESH, ETC., FREED FROM BONE, SHELL, AND OTHER REFUSE.

KINDS OF FOOD MATERIALS. (*Italics* indicate European analysis; the rest are American.)	Water.	Total Nutrients.	NUTRIENTS. Nitrogenous (albuminoids).	Fats.	Carbo-hydrates.	Ash.
MEATS, Fresh.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.
Beef, side, well fattened	54.6	45.4	17.2	27.2	...	1.0
Beef, lean, nearly free from fat	76.0	24.0	21.8	0.9	...	1.3
Beef, round, rather lean	66.7	33.3	23.0	9.0	...	1.3
Beef, sirloin, rather fat	60.0	40.0	20.0	19.0	...	1.0
Beef, neck, "second cut"	64.5	35.5	19.9	14.5	...	1.1
Beef, liver	69.5	30.5	20.1	5.4	3.5	1.5
Beef, tongue	63.5	36.5	17.4	18.0	...	1.1
Beef, heart	56.5	43.5	16.3	26.2	...	1.0
Veal, lean	78.8	21.2	19.9	0.8	...	0.5
Veal, rather fat	72.3	27.7	18.9	7.5	...	1.3
Mutton, side, well fattened	45.9	54.1	14.7	38.7	...	0.7
Mutton, leg	61.8	38.2	18.3	19.0	...	0.9
Mutton, shoulder	58.6	41.4	18.1	22.4	...	6.9
Mutton, loin (chop)	49.3	50.7	15.0	35.0	...	0.7
MEATS, Prepared.						
Dried Beef	58.6	41.4	30.3	4.4	...	6.7
Corned Beef, rather lean	58.1	41.9	13.3	26.6	...	2.0
Smoked Ham	41.5	58.5	16.7	39.1	...	2.7
Pork, Bacon, salted	10.0	90.0	3.0	80.5	...	6.5
FOWL.						
Chicken, rather lean	72.2	27.8	24.4	2.0	...	1.4
Turkey, medium fatness	66.2	33.8	23.8	8.7	...	1.3
Goose, fat	38.0	62.0	15.9	45.6	...	0.5
DAIRY PRODUCTS, EGGS, ETC.						
Cow's Milk	87.4	12.6	3.4	3.8	4.8	0.7
Cow's Milk, skimmed	90.7	9.3	3.1	0.7	4.8	0.7
Cow's Milk, buttermilk	90.3	9,7	4.1	0.9	4.0	0.7
Cow's Milk, whey	93.2	6.8	0.9	0.2	5.0	0.7
Cheese, whole milk	31.2	68.8	27.1	35.4	2.4	3.9
Cheese, skimmed milk	41.3	58.7	38.3	6.8	9.0	4.6
Butter	9.0	91.0	1.0	87.5	0.5	2.0
Hen's Eggs	73.1	26.9	13.4	11.8	0.7	1.0
FISH, ETC.						
Flounder, whole	84.2	15.8	13.8	0.7	...	1.3
Haddock, dressed	81.4	18.6	17.1	0.3	...	1.2
Bluefish, dressed	78.5	21.5	19.0	1.2	...	1.3

KINDS OF FOOD MATERIALS. (*Italics* indicate European analysis; the rest are American.	Water.	Total Nutrients.	NUTRIENTS. Nitrogenous (albuminoids).	Fats.	Carbo-hydrates.		Ash.
FISH, ETC.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.		Per ct.
Cod, dressed	82.6	17.4	15.8	0.4	...		1.2
Whitefish, whole	69.8	30.2	22.1	6.5	...		1.6
Shad, whole	70.6	29.4	18.5	9.5	...		1.4
Mackerel, average, whole	71.6	28.4	18.8	8.2	...		1.4
Salmon, whole	63.6	36.4	21.6	13.4	...		1.4
						Salt	
Salt Cod	53.8	26.1	21.7	0.3	...	20.1	4.1
Smoked Herring	34.5	53.8	36.4	15.8	...	11.7	1.6
Salt Mackerel	42.2	47.2	22.1	22.6	...	10.6	2.5
Oysters	87.2	12.8	6.0	1.2	3.6		2.0

VEGETABLE FOODS.

KINDS OF FOODS.	Water.	NUTRIENTS. Nitrogenous (albuminoids).	Fats.	Carbo-hydrates, etc.	Wood fiber.	Mineral Matters.
FOODS.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.
Wheat-flour, average*	11.6	11.1	1.1	75.4	0.2	0.6
Wheat-flour, maximum*	13.5	13.5	2.0	78.5	1.2	1.5
Wheat-flour, minimum*	8.3	8.6	0.6	68.3	0.1	0.3
Graham-flour (wheat)	13.0	11.7	1.7	69.9	1.9	1.8
Cracked Wheat	10.4	11.9	1.7	74.6		1.4
Rye-flour	13.1	6.7	0.8	78.3	0.4	0.7
Pearled Barley	11.8	8.4	0.7	77.8	0.3	1.0
Buckwheat-flour	13.5	6.5	1.3	77.3	0.3	1.1
Buckwheat "farina"	11.2	3.3	0.3	84.7	0.1	0.4
Buckwheat "groats"	10.6	4.8	0.6	83.1	0.3	0.6
Oatmeal	7.7	15.1	7.1	67.2	0.9	2.0
Maize-meal	14.5	9.1	3.8	69.2	0.8	1.6
Hominy	13.5	8.3	0.4	77.1	1.3	0.4
Rice	12.4	7.4	0.4	79.2	0.2	0.4
Beans	13.7	13.2	2.1	53.7	3.7	3.6
Peas	15.0	22.9	1.8	52.4	5.4	2.5
Potatoes	75.5	2.0	0.2	20.7	0.8	1.0
Sweet Potatoes	75.8	1.5	0.4	20.0	1.1	1.2
Turnips	91.2	1.0	0.2	6.0	0.9	0.7
Carrots	87.9	1.0	0.2	8.9	1.2	0.8
Cabbage	90.0	1.9	0.2	4.9	1.8	1.2
Cauliflower	90.4	2.5	0.4	5.0	0.9	0.8

* Of analyses of American flours.

KINDS OF FOODS.	Water.	NUTRIENTS. Nitrogenous (albuminoids.)	Fats.	Carbo-hydrates, etc.	Wood fiber.	Mineral Matters.
FOODS.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.
Melons	95.2	1.1	0.6	1.4	1.1	0.6
Pumpkins	90.0	0.7	0.1	7.3	1.3	0.6
Apples	84.8	0.4	0.0	12.8	1.5	0.5
Pears	83.0	0.4	0.0	12.0	4.3	0.3
Starch	15.1	1.2	0.0	83.3	0.0	0.4
Cane Sugar	2.2	0.3	0.0	96.7	0.0	0.8
Wheat-bread*	32.7	8.9	1.9	53.5		1.0
Graham-bread	34.2	9.5	1.4	53.3		1.6
Rye-bread	30.0	8.4	0.5	59.7		1.4
Soda Crackers	8.0	10.3	9.4	70.5		1.8
"Boston" Crackers	8.3	10.7	9.9	68.7		2.4
"Oyster" Crackers	3.9	12.3	4.8	76.5		2.5
Oatmeal Crackers	4.9	10.4	13.7	69.6		1.4
Pilot (bread) Crackers	7.9	12.4	4.4	74.2		1.1
Maccaroni	13.1	9.0	0.3	76.8		0.8

* From flour of about average composition.

According to a recent French statistician, a man living for fifty years eats during that time 79,000 pounds of bread, 16,000 of meat, 4,000 of vegetables, eggs, and fish, and requires 7,000,000 gallons of water; for fifty-nine per cent. of the entire body is composed of water, which must, therefore, be introduced into the system in about that proportion, in our foods, to keep the organism in proper working order, not only keeping the tissues moist and succulent, but by washing out effete matters as well.

Water, as the most important of the inorganic foods, also deserves our careful attention, not only because it composes the bulk of our bodies, but because it is the agent by which many of the ills of the house in which we live are brought to pass. Long ago the human body was defined as forty-five pounds of solid matter diffused through five and a half pails of water. This is not absolutely exact, but the annexed table shows that water is found in all of the tissues though in widely varying proportions:

PARTS IN A THOUSAND OF WATER AND SOLIDS. (*Besanez.*)

	Water.	Solids.		Water.	Solids.
Enamel of the teeth	2	998	Nerves	780	220
Teeth	100	900	Blood	791	209
Bones	220	780	Cellular tissue	796	204
Fat	299	701	Kidneys	827	173
Elastic tissue	496	504	Bile	864	136
Cartilage	550	450	Milk	891	109
Liver	693	307	Chyle	928	72
Spinal cord	667	333	Mucus	934	66
Skin	720	280	Lymph	983	17
Brain	750	250	Spinal fluid	988	12
Muscles	757	243	Saliva	995	5
Spleen	758	242	Sweat	998	2

If, therefore, all the water could be extracted from a body it would weigh less than half of what it does during life, and if kept from moisture it might be preserved almost indefinitely. Buckland, in his *Curiosities of Natural History*, tells the following story:

"In the College of Surgeons is the dried body of a poor boy that was found bricked up in a vault in a London church. This boy was about twelve years of age. He was found erect, with his clothes on, in a vault underneath Saint Botolph's, Aldgate, old church, in the year 1742, and is supposed to have been shut in during the plague in London, in 1665, as the vault had not been opened since that period till it was pulled down. This body weighs only eighteen pounds."

A man loses about two quarts of water a day, about a quarter of which passes off by the lungs, and the remainder by the skin and kidneys. (See Sewerage.)

To supply this loss we are required to drink in foods and liquids about one thousand pounds per year, or during an average life-time a man drinks up an 800-foot lake. All of this is not derived solely from liquids, for it is found in grains that are usually spoken of as dry. It abounds in meats, vegetables, and fruits. We obtain about thirty-eight per cent. of it in bread, seventy per cent. in lean meat, from seventy to ninety per cent. in vegetables, and even more in some fruits. Indeed, if we used all these in a natural

state, there would not be need of very much additional supply. Extra water, as we need, we derive from the earth or from the sky. From either source by care we may secure pure and most acceptable water for the needs of the body (see Chapter VI), but this is a different matter from pouring down a large amount of fluid with each meal, as is the American custom. As more than one half of our food is water we need very little while eating, when its use is mischievous in that it is used as a substitute for saliva (page 78) and still further interferes with digestion by unduly diluting the gastric juice. Even when this is not the case large draughts of water in hot weather tend to produce profuse perspiration, and thus aggravate the very evil it is designed to relieve. Especially is this true in the case of ice water, whose use inevitably produces dryness of the throat and desire for more, until the quantity seriously disables the stomach, and may even produce death, when taken into an over-heated system. Small draughts of water, slowly taken, satisfy thirst better than large ones quickly swallowed. In fact, thirst, or dryness of the throat, often mistaken for thirst, may be as well relieved by gargling the throat with hot water as by drinking it, and thirst, or the general demand of the body for fluid, can be relieved without drinking at all. Injection of fluids, or the application of water to the skin, even if it be salt water, will relieve if not entirely remove thirst; a fact well worth knowing in shipwreck. In an old book, published in 1769, entitled *The Narrative of Captain Kennedy's Losing His Vessel*, may be found the following, bearing on this subject: "I cannot conclude without making mention of the great advantage received from soaking my clothes twice a day in salt water and putting them on without wringing. It was a considerable time before I could make my people comply with this measure, although from seeing the good effects produced they practiced it twice a day of their own accord. To this I may with justice lay my preservation and that of the six other persons with me. Four persons in the boat who drank salt water went delirious and died." Prob-

ably none of the readers of this will ever be driven to Captain Kennedy's strait, but as we must all drink, it is important that the water taken daily should be sufficient to keep the kidneys well at work and the skin moist in hot weather. Drink sparingly at meal-time, and drink *pure* water. The last is often the most difficult and important, for there can be but little doubt that typhoid and cholera are usually introduced into the system by means of drinking water. In case of the last outbreak of cholera its spread is clearly traced by Dr. Cutliffe to the Hindoo pilgrims assembled at Hurdwar, a few miles from the spot where the Ganges escapes from the Himalayas, of whom a handful had come from a cholera district.

On the 12th of April the three millions assembled to bathe and drink. "The bathing-place of the pilgrims was a space six hundred and fifty feet long by thirty feet wide, shut off from the rest of the Ganges by rails. Into this long, narrow inclosure pilgrims from all parts of the encampment crowded as closely as possible from early morn to sunset; the water within this space, during the whole time, was thick and dirty—partly from the ashes of the dead brought by surviving relatives to be deposited in the water of their river god, and partly from the washing of the clothes and bodies of the bathers. Now, pilgrims at the bathing ghaut, after entering the stream, dip themselves under the water three times or more, and then drink of the holy water, while saying their prayer. The drinking of the water is never omitted; and when two or more of the family bathe together, each from his own hand gives the other water to drink. On the evening of the next day, the 13th of April, eight cases of cholera were admitted into one of the hospitals at Hurdwar. By the 15th, the whole of this vast concourse of pilgrims had dispersed," carrying the cholera in every direction over India; it attacked the British troops along the various routes, it passed the northern frontier, got into Persia, and so on into Europe."

If space allowed, similarly well authenticated cases of the

spread of typhoid from particular wells or rivers, contaminated with typhoid excreta, could be given. But these are not necessary, for it is so well proven that drinking water is often poisonous that pure water is now universally sought, for large cities, at some distance from them if at all possible. For such drinking, rain, spring, river, lake, or well water is employed, and of these the last is usually the most objectionable. If it were not for the disagreeable taste which rain-water acquires by standing in hogsheads or cisterns it would undoubtedly be the best, as it is the purest, and in all cases of epidemic disease, where there is the least doubt about the purity of the water supply, filtered rain water should be used without regard to its taste. Spring and river water are pleasanter for drinking, from the fact that they usually contain carbonic acid gas in solution—sometimes as much as one gallon to twenty-five of water—which imparts to them a brightness and freshness which rain-water does not possess, for this gas comes mainly from the decomposition of vegetable matter in the earth. So long as this is the only substance found in solution in drinking water it does it no hurt, but rather improves, but where carbonic acid gas is found in large quantity with it is generally joined an excess of inorganic salts. When these are found in smaller quantities than forty grains to the gallon the water is said to be potable, unless it contains albuminoid ammonia, or foul-smelling gases. Albuminoid ammonia is that contained in water, not as free ammonia, but that which may be obtained from the nitrogenous compounds held in the water by heating it with a caustic alkali. Warming water containing a considerable amount of decomposing matter will cause it to give disagreeable odors which otherwise would have escaped detection; nor should water that is fit for drinking give any odor when in a closed half-filled bottle for several days.

"The best water for drinking," says Dr. Hunt, "is that which is mingled with pure air, which is free from any organic animal or vegetable matter, either solid or gaseous, and which does not hold in suspension or solution any mineral matter.

Water is frequently colored by vegetable matters, and yet the amount is such as to be easily neutralized or discharged from the system without evil effects. It is only when vegetable matter is in a state of decay that there is much risk. The same is true as to animal matter or excretions, which are in general more dangerous than vegetable matters. It is chiefly so when undergoing active putrefactive change, and especially when it contains those living vegetable micro-organisms which are now recognized as associated with disease. It is found that both air and water abound with minute forms either of animal or vegetable life. To distinguish them from gaseous products, they are usually called 'particulate,' as made up of particles. These are intended to be conservative of life and health by feeding and nourishing upon those things not needed by man and injurious to him. But when air and water are subjected to very abnormal conditions, and are continuously and extravagantly befouled, either these low forms of life multiply to an amount which nature cannot dispose of, or new and virulent forms spring up, which, getting into the system through air or water, give rise to specific forms of disease."

The taste of water is not always a safe guide to its use, for dangerous drinking water may be cool and sparkling and yet defiled with privy drainings, or other impurities. Such water often becomes fetid by merely standing, but a better and a very simple test is Heisch's, which can be readily applied in any household. It consists of simply dissolving in three quarters of a pint of the suspected water half a teaspoonful of loaf sugar and placing the solution in a corked pint bottle in a warm place for a couple of days. If at the end of that time it is found transparent it may be considered fit for drinking, for if the water had contained sufficient impurities to produce fermentation of the sugar, it turns the liquid cloudy or turbid. Furthermore, safe water for drinking ought to respond to such a color test as may be made by filling completely with the water a large bottle made of colorless glass; look through the water at some black object;

the water should appear perfectly colorless and free from suspended matter. A muddy or turbid appearance indicates the presence of soluble organic matter or of solid matter in suspension. Nor should good water give any *odor* when thus tested; empty out some of the water, leaving the bottle half full; cork up the bottle and place it for a few hours in a warm place; shake up the water, remove the cork, and critically smell the air contained in the bottle. If it has any smell, and especially if the odor is in the least repulsive, the water should be rejected for domestic use. By heating the water to boiling, an odor is evolved sometimes that does not otherwise appear.

As a large portion of the water thus found unfit for drinking comes from old wells, it might be helpful in this connection to call the attention of the reader to the conclusions arrived at some years ago by Mr. Cutler, a chemist who examined the water of twenty-four wells in New Brunswick, N. J.:

"A well may be considered as a perpendicular drain, and as such we can readily perceive that it becomes a receptable for all surface-water in its vicinity. One might suppose that a well dug in a sandy soil or clayey soil would be thus subject to impurities, but when constructed through rock or shale it would be entirely free from such contamination. This, however, is not always the case, for although rock may form some protection, still impure waters are often found in wells built entirely through stone.

"The water drawn from the surface of the well is often quite pure, while that drawn from the bottom is greatly contaminated, showing that good and bad waters may exist in a well at the same time, owing to the difference in their specific gravities.

"Although the soil in which cess-pools are dug may be able to retain the sewage for a long time, still the ground gradually becomes saturated, and, acting as a sponge, the impure water is carried for many yards, until, perhaps, it strikes a well into which it may drain.

"Persons living on high ground may suppose their wells to be free from such impurities, not knowing that the barn-yard or cess-pool may be one of the springs from which their water is obtained.

"Wells constructed in the usual manner are particularly apt to contain bad water—first, from drainage, as I have just illustrated; and secondly, from the decay of animals or reptiles which have fallen in them. The stones lining the wells are so rudely put together that ample room is allowed for toads, snakes, snails, etc., to collect, and hence frequently fall into the water and perish. It is stated by well-diggers that generally they find at the bottom of old wells eight to sixteen inches of mud, containing the decaying *débris* of these unfortunate creatures. It is therefore of the utmost importance that wells be so constructed that the water may be as free as possible from all drainage and contamination caused by the decay of small animals.

"It is almost impossible to construct a well from which water known to be absolutely pure can be obtained. Hence, an analysis of well-water is of much importance as the only method of establishing the purity of the water.

"If a water contain over forty grains of solid matter to the gallon, it is generally injurious to health. Such an amount is always suspicious, and demands investigation to ascertain if the matter is organic or inorganic."

Returning to table of foods, pages 63–65, we find them divided into ash, carbohydrates, fat, and albuminoids, or (1) Albuminoid, or nitrogenous; (2) Non-nitrogenous, or fats, etc., the function of the first being to form and repair muscles, while the non-nitrogenous furnish the body's fuel. These fats and carbo-hydrates (sugar and starch) are hardly less important, for although they do not form muscle they are necessary for the production of heat and to fatten the body. They correspond in value nearly to the coal which the fireman shovels into the furnace of an engine, and without which it is unable to do its work. Finally, in the column headed "Ash," we find (3) salts, or the inorganic parts, except

water, of our usual foods. These salts are mainly the phosphate of lime and the sulphates, chlorides and phosphates of potassium and sodium, together, with smaller quantities of the salts of magnesium, iron, and manganese. Such salts are essential to the proper formation of bone, and if kept from the growing child it becomes rickety and deformed. All of them, except common salt—chloride of sodium—exist in sufficient quantities for health in our ordinary foods. There seems to be a natural and instinctive longing for salt by the herbivora and man, for wild animals will travel long distances to enjoy a salt lick, and among savage nations salt often brings the highest price of all commodities. Physiologists tell us that salt is necessary for cell activity, so that this instinctive longing for salty food is natural, but this is not true of pepper, mustard, and other condiments. These are acquired tastes, and only required by those whose jaded appetites require a spur.

Both foods and the human body may in their chemistry be compared to an egg. The comparison is good in that each may be divided into groups represented by the shell, white, and yelk of the egg. The first of these are the inorganic constituents of the body, a list of which is given below.

GROUP 1, or the shell group, includes in the human body:

1. *Water.*—Placed first, because about ninety pounds in an average adult body.

2. *Gases.*—Oxygen, hydrogen, nitrogen, carbon dioxide, marsh gas, sulphuretted hydrogen.

3. *Salts.*—Sodium chloride, potassium chloride, ammonium chloride, calcium fluoride, sodium carbonate, potassium carbonate, ammonium carbonate, calcium carbonate, magnesium carbonate, sodium phosphate, potassium phosphate, calcium phosphate, magnesium phosphate, ammonio-magnesium phosphate, ammonio-sodium phosphate, nitrate of ammonia, ammonium sulphate, alkaline sulphates, calcium sulphate.

4. *Free Acids.*—Hydrochloric acid, sulphuric acid.

5. *Silicon, iron, manganese, copper, lead.*

The exact role each of these performs in the body is not yet definitely known; in fact, it is not yet even known in what combinations the members of the fifth group are found in the body. But it is known wherever cell formation takes place in the body there certain of the inorganic salts are necessary. Calcium phosphate, for instance, is not only necessary for the development of bone, but of all albuminoid tissues. Sodium chloride is always found where cell activity is great. The exchange of inorganic gases will be alluded to under the subject of respiration.

GROUP 2 contains those compounds, analogous to the white of the egg found in the human body, and known in general as albuminoids. They are uncrystallizable, without definite chemical composition, and resemble in many of their reactions the white of an egg, whence their name. The number of these compounds is large. They are fluid, semi-solid, and solid, and include such substances as seralbumen, fibrine, the digestive ferments, globulin, chrondrogen, ostein, keratin, and various pigments of more interest to the physiological chemist than to the general student.

GROUP 3, the yelk group, includes the sugars and the fats and starchy compounds of the body; or, in other words, this group embraces the non-nitrogenous carbon compounds.

This division of the body is helpful, for the reason that it is about the same division as that previously adopted for foods; namely, nitrogenous, carbo-hydrates, and inorganic, each of whose digestion requires a different process to make them part of their most nearly resembling constituents of the body. As the starchy foods (Group 2) are those first acted upon by the digestive fluids, it may be well to begin our consideration of the assimilation of foods with those which make up no small bulk of our every-day fare. About seventy per cent. of the best bread, potatoes (seventy-five per cent.), oatmeal, hominy, and Indian corn in less proportion, are starchy matters which require cooking and chemical change before they can be used in the body. Cooking bursts the envelopes in which the starch granules are contained.

hydrates them if moisture is added, or if dry heat alone is employed changes white, insoluble starch to a soluble fawn-colored substance known as dextrine. This is the reason why toasted bread or cracker is more digestible than bread. Cooking also separates the fiber of food, and thus renders it more amenable to the action of the digestive fluids. Pork is less digestible than beef and mutton, largely because the fibers of the former are more compact than the latter, for if thoroughly cooked and properly masticated pork ranks among the best of our foods.

Mastication, or, in plain English, chewing, is the first act in the process of digestion. For this purpose the mouth of an adult is provided, or ought to be, with thirty-two teeth, and should secrete something over a quart of saliva a day. The form of the teeth proves that they are to bite, to cut, and to grind; and hence that man is an omnivorous animal. If we judge from the care displayed in their structure and their chemistry, the teeth ought to be the last part of the skeleton to decay. It is so after death, and ought to be before ; but the fact is that Americans have the worst teeth and the best dentists of any nation upon the face of the earth. A variety of dissimilar causes, such as candy, hot drinks, ice water, patent flour, etc., have been considered by different writers as the cause, but the probability is that, while these may be exciting causes, the real error lies in our ways of living. Poor teeth inevitably accompany poor bones and flabby muscles, and if we should return to the simpler and better ways of living of our grandfathers we should in all probability have their good teeth. But, having poor teeth, all the greater need of preserving them; and this care should begin in childhood. A tooth-brush and tooth-pick should be considered as indispensable to a child as a handkerchief, and it should be taught to use them as diligently. The first or milk teeth should not be prematurely removed, but allowed to remain as long as possible, filling with cheap fillings if necessary to preserve the contour of the jaw. It should also be remembered that the six year

molars are never replaced. They follow so closely the temporary teeth that they are often confounded with them and allowed to decay under the mistaken idea that they will be replaced by permanent teeth later. Permanent teeth in this country ought to be inspected by a competent dentist every six months at least, in order that the beginnings of decay may be arrested. Waiting to attend to a carious tooth until forced to by toothache is very like waiting until a house is afire before putting insurance upon it.

To understand why a tooth aches so violently when once it begins requires some knowledge of the structure of teeth. Pain usually implies pressure upon or poisoning of nerve structure. In the case of the toothache it is clearly the former, as a tooth is composed, from the outside, first of enamel, second of dentine and cementum, and in its center a pulp cavity designed to hold the nerve of the tooth. So long as the tooth remains sound the nerve rests comfortably there, but let the enamel once crack and allow food to find lodgment and breed bacteria (see Chapter VIII) the dentine soon breaks down and allows the nerve to be exposed to the air, or otherwise inflamed. The nerve then becomes larger and presses against the bony walls of its cavity until the pain becomes almost unbearable. But suffering does not remove the pain; we are obliged to seek the dentist to extract the tooth which he ought to have been called upon previously to save.

The enamel which covers the teeth is the hardest substance found in the body, and so long as it remains unbroken it is well-nigh indestructible. The microscope shows it to be constructed of a multitude of hexagonal prisms, so hard and packed so tightly together that, like flint, they will strike fire. The bulk of a tooth is made up of wavy tubes of dentine with cementum gluing it to the jaw, and inside of the tooth the pulp cavity already described. Killing the nerve of a tooth means introducing into this cavity some substance, such as arsenic, which will destroy the vitality of the nerve. The objection to this is that the tooth then becomes a foreign

body in the gum, where it is very liable to set up inflammation. In fact, such dead teeth are prone to make more trouble than false teeth, which, by the way, are no modern invention, for the Chinese, long before we ever dreamed of such things, whittled out of hard wood artificial teeth to order, as they do till to-day; their tooth carpenters, according to Dr. Clancy, sitting on the street corners to turn you out a set while you wait. False teeth were known to the Romans, for in one of Horace's odes he speaks of two belligerent hags falling into a quarrel, and in the excitement of the occasion the false teeth of one of them falls out. Gold fillings are as old as the Egyptians, for some of their mummies have their teeth filled with gold, and well filled, too, we are told.

False teeth are better than no teeth, but it is far better to preserve even a poor set than to be compelled to rely on porcelain substitutes, for at their best they can never as perfectly masticate food as it should be done. Rinsing the mouth immediately after a meal with a dilute solution of common baking soda (saleratus), a pinch in half a glass of water, and the use of a good tooth-brush and tooth-picks freely in private, would save most of us many an hour's pain at the dentist's. In addition at bed-time a piece of waxed silk ought to be drawn between the teeth, wherever food might gather and decay. Nature's teeth ought to serve us as long as we have any occasion for them. But all this requires more time than busy Americans think they can give to the care of so trivial a matter as their teeth, until at last an exposed nerve or an inflamed pulp cavity drives them to the nearest dentist, quoting energetically Burns's "Ode to the Toothache" as they go.

A tooth is too valuable a servant to be lightly lost, so that if a sound one is by some mischance pushed from its socket it ought to be immediately replaced, and if possible held there, for the gums sometimes contract with sufficient firmness to hold the tooth again in place and enable it to do very fair work. In fact, the original method for the use of

artificial teeth was to extract a stump and immediately insert a false tooth in its stead, which often was held with sufficient firmness to enable it to bite or grind the food according as it was an incisor or molar.

The molars, like the mills of the gods, are intended to grind slowly and exceeding fine, for the efficiency of after digestion depends largely upon the smallness of the fragments of food and their thorough mixture with the fluids of the mouth, or insalivation, as it is sometimes called. These fluids come in part from the mucous glands of the mouth (see Chapter V) and in part from the salivary glands. Two of the latter are located beside the ear (parotid), two beneath the jaw (submaxillary), and two beneath the tongue (sublingual). Together they secrete about a quart of liquid, which is continually being poured into the mouth through the ducts leading from these glands. The ducts of the sublingual and submaxillary glands, near together, open into the mouth just beneath the tongue, while the ducts of the parotids pour their saliva into the mouth through openings nearly opposite the second of the molars of the upper jaw. With the tip of the tongue the saliva can be felt continually trickling out of these apertures, and greatly increased in quantity while dining, or when the mouth "waters" for something good to eat.

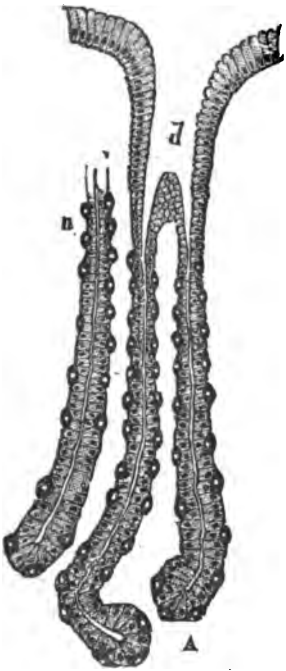
The purpose of the saliva is twofold: first, to thoroughly lubricate the food so that swallowing may be easy, and second to bring about a chemical change in the starch of the food which transforms it into a variety of sugar (glucose) which can be utilized in the body. If for any reason this is not accomplished, either because the food is not finely enough ground by the teeth, or because the saliva is deficient in quantity or quality, starchy indigestion results, and hence for many dyspeptics bread is the most difficult thing to digest. Young infants have little or no saliva, and hence are unable to properly digest starchy food. Although small quantities may be disposed of lower down in the alimentary canal, the bulk of these starchy foods remains undigested and causes

innumerable infantile colics and not a few deaths. The majority of patent infant foods are starchy in their nature, and hence evil in their effects. Milk, properly prepared, is the best food for babies for the reason that it contains all the necessary elements of food mentioned on page 73, namely, inorganic salts, albuminoids (casein or curd) and hydrocarbons in the cream and sugar of the milk.

Let us then briefly consider the digestion in detail of a mouthful of milk, since it contains all the ingredients necessary for the nourishment of the body and all the essential varieties of food that can be found on any table. Undigested milk is poison, as many a poor baby has found to its cost, but properly digested it forms bone, muscle, sinew, by the aid of the germinal matter spoken of in Chapter I. Each kind of germinal matter needs its appropriate nourishment, all of which can be gathered from the curd, cream, and salts of the milk.

First, as to the curd, which corresponds to the nitrogenous foods of the adult. With the latter the nitrogenous food requires to be reduced to small fragments by the teeth before it descends the esophagus, or the back stairs to the kitchen. Liquids escape this process, and immediately find their way over the epiglottis (see Chapter VI) down into the stomach, whose acid juices immediately clot it. If these clots are too large, or firm, they cause distress, but if the milk is properly acted upon it forms soft, fine curds, which are more digestible than the original milk, for they contain their nitrogenous matter in a form to be readily acted upon by the gastric juice. Gastric juice is an acid fluid constantly secreted by glands located in the membrane lining the inside of the stomach. These are known as the peptic glands, and their duty is to prepare the gastric juice, or fluid, which is a colorless, watery, acid liquid containing from three to four parts in a thousand of pepsin. Pepsin is an animal ferment, and has the remarkable property of transforming albuminoids into peptones. A solution of peptone looks very like a solution of albumen, from which it differs mainly in the fact that albumen is unable to pass

through an animal membrane, while peptone can. On this apparently trivial fact the use of animal food depends. If it were otherwise all animal and much vegetable food would have to be given up, for unless it can be transformed into something which will nourish the body by passing into the circulation such food would be positively injurious. Unchanged albuminoids would lie like lead in the stomach, for albuminoid bodies cannot pass through the coats of the stomach into the blood, where it can nourish and supply the body's waste. Peptone is an hydration of the albumen, prepared by the pepsin of the stomach. Thus peptonized, as we say, assimilation can now go on by absorption of the albuminoids which have been peptonized, which pass as peptones directly into the lacteals located in the walls of the stomach. The exact work done by the stomach was for a long time a mystery to the chemist; some esteeming it, as Hunter says, a cooking pot, others a mill, a churn, etc., until very recently the exact chemical change occurring there is found to be simply the addition of water to the albuminoids of the food—not a mixture with water, for that takes place in the mouth; but a chemical union, or hydration, forming the peptones already described.



PEPTIC GLANDS.
A, Under a low power; *d*, duct; *n*, neck.—*Klein*.

But all of our food is not albuminoid, and hence not digested in the stomach, whose fluids are only able to peptonize the nitrogenous foods. The starches have partly been acted upon by the saliva in the mouth, and this trans-

formation into glucose is further continued in the acid fluids of the stomach, while the remainder of the food is in from two to six hours converted into a thick fluid, consisting of solid, undigested particles, suspended in a yellowish, disagreeably smelling liquid. This mixture is known as chyme, and is food now prepared for further digestion in the intestinal canal, into which it passes from the stomach by means of the pylorus, a purse-like mouth which opens when the chyme is ready for intestinal digestion. When in the intestines it becomes mixed with bile, pancreatic fluid, and the juices from the various intestinal glands. Each of these has some part to perform in perfect digestion. The bile, for instance, prevents decomposition, and emulsifies the fats, the pancreatic fluid completes the digestion of the fats, and the intestinal fluids complete the digestion of the albuminoids and sugars. The use of each of the digestive ferments is well shown in the following table taken from Roberts:

TABLE OF DIGESTIVE FERMENTS.

NAME.	FUNCTION.
1. *Ptyalin*, or salivary diastase, contained in the saliva.	1. Changes starch into dextrine and glucose.
2. *Pepsin* contained in gastric juice.	2. In acid fluids changes albuminoids into peptones.
3. *Curdling ferment* contained in gastric juice.	3. Coagulates casein.
4. *Trypsin* contained in pancreatic juice.	4. In alkaline solutions transforms proteids to peptones.
5. *Curdling ferment* found in pancreatic juice.	5. Coagulates milk casein.
6. *Pancreatic diastase* found in pancreatic juice.	6. Changes starch into dextrine and glucose.
7. *Emulsive ferment* found in pancreatic juice.	7. Emulsifies fats.
8. *Bile* poured into duodenum.	8. Assists in emulsifying fats.
9. *Invertin* found in intestinal juice.	9. Converts cane sugar into inverted sugar.
10. *Curdling ferment* found in intestinal juice.	10. Coagulates casein.

Digestion, then, is not as simple a thing as the proprietors of the patent anti-dyspeptics would have you believe. It is an exceedingly complex process, and any interference at any stage of the process produces dyspepsia, which is the Greek

for indigestion. Eupepsia is the word for perfect digestion, and any variation from this constitutes dyspepsia, which may be of all grades from slight discomfort after eating to a profound wretchedness which makes life a burden. It may be a dyspepsia arising from failure to properly masticate the food from lack of teeth, or haste, and can be remedied only by false teeth, or greater care in eating; and unless this is done no amount of artificial pepsin will cure the difficulty.

Pepsin, by the way, is no new remedy, for the Chinese from time immemorial have used a decoction of chicken gizzards in just those cases where the modern physician employs ingluvin manufactured from the same source, but neither pepsin, ingluvin, lactopeptin, dyspepsin, nor any of the vaunted panaceas for dyspepsia will accomplish their work without the intelligent assistance of both patient and physician. Chronic dyspepsia and sick headaches, which are probably another manifestation of the same vice, are among the most intractable of human ailments. No one acquires either without prolonged errors in eating. Gluttony causes as much, if a different kind, of distress as drunkenness, and it is a form of intemperance to which intelligent people are vastly more prone than indulgence in liquor. Others than Methodist theological students might read to profit John Wesley's rules on this subject, beginning with, "Are you temperate in all things? For instance, in food, do you use only that kind and that degree which is best both for body and soul? Do you see the necessity of this? Do you eat no more at each meal than is necessary? Are you not heavy or drowsy after dinner?" It is not the amount of food eaten, but that assimilated, which feeds the body, and any excess over this is hurtful and harmful. We possess about four millions of cooks, whose duty is to prepare food for us, and so excellently will they do this if we furnish them the proper materials that we ought to know nothing more of their exploits than we do of the same class of workers in a large hotel. Dyspepsia means a strike in the

kitchen, and may be of any magnitude, from slight inconvenience to absolute starvation. Usually the first evidence of trouble in the human kitchen is loss of appetite, or anorexia, as the doctors call it.

If now we were only wise enough to understand that a lack of appetite means that our cooks have been overtaxed and are meditating further disturbance, happy would it be for us and them, but, instead, we send down additional dainties for them to dispose of. The next thing, if we persist in this course, is a serious emeute below stairs, for which we are solely to blame; for if we had refrained from eating for a meal or two, as our loss of appetite counseled us to do, appetite would have returned at the proper time, and we should have been all the better for our temporary fast. Long ago old Dr. Dewees wrote: "I am convinced that the value of abstinence in the treatment of acute disease is not fully appreciated," and every physician since has had no lack of cases corroborating this. Food in this country is so plentiful and excellent that we eat too much, and where one poor unfortunate dies of starvation hundreds die of overeating.

According to Dr. Hunt, a person engaged in hard work requires not more than four and a half ounces of meat, or its equivalent, and about twenty-six ounces or two pounds of well-buttered bread, or its equivalent, to efficiently perform his daily work; and this is rather below than above the amount of meat, vegetables, etc., eaten in this country by those engaged in sedentary pursuits. To enable the digestive organs to perform this surplus work, condiments, sauces, and artificial aids are generally employed, to the permanent injury of the individual, often in the shape of permanently disabled kidneys. (See Sewerage.)

Finally, there is what is known as nervous dyspepsia, a disease of increasing frequency in our large cities. In these cases the trouble seems to be not with the food, but with the nerves which regulate the supply of gastric juice. Excitement of any kind will bring a transient nervous anorexia, and if the excitement be long-continued this loss of appe-

tite may become permanent. It is one form of neurasthenia, elsewhere spoken of (see Chapter VII), and needs similar treatment. Drugs, tonics, and stimulants, too often resorted to with temporary relief in these cases, are all useless until some method is found to restore the exhausted nervous system. Stimulants here are particularly hurtful, for they inevitably inflict permanent injury on the already weakened digestive organs. A glass of wine or a sip of something stronger in such cases will often stir up a lagging appetite, and enable one of these exhausted stomachs to dispose of a fair meal which otherwise would have gone begging. But such temporary relief is purchased at the price of further exhaustion on the withdrawal of the stimulant, which unfortunately often is never withdrawn until the dyspeptic finds himself in worse bondage to alcohol.

The exact relation of alcohol to food is a question that has long and vehemently been argued over, and is not yet fully settled. It can, however, be fairly said that its estimation as a food has gradually diminished until now even its advocates scarcely claim more than that alcoholic drinks take the place of food, and are of value to those wasting from disease or enduring great hardships. The last claim has never been substantiated, but, on the contrary, many facts have been educed which prove the exact reverse. The *London Times*, which can hardly be supposed to be prejudiced in favor of temperance, reports that the total abstainers on a recent Arctic expedition bore the terrible severities of their long sledge journeys better than those to whom grog was daily served. The experience of one of these abstainers is so much to the point that it is given in detail.

"Gore, it seems, had been an abstainer until he was twenty-one years old, but in an unguarded moment while on the sledge journeys he succumbed to the temptation and persuasion of his companions and took to grog. Previous to breaking his pledge Gore states that he could eat as well as any one. In fact, after devouring his portion, he was in the habit of looking about for more; but no sooner had he taken

to grog-drinking than he found his appetite to fail, and he was deprived of the refreshing sleep which he had formerly enjoyed. He was the only Good Templar who joined the expedition that was attacked with scurvy, and for this he was no doubt indebted to his unfaithfulness. He gave stimulants, he remarks, a fair trial, and he is now convinced that it was the grog which did the mischief. It may be noticed that the testimony of the whole ship's company—doctors and others included—is unanimous and conclusive against the serving out of stimulants during the day. They emphatically state that no work can be done upon the grog."

Furthermore, the medical profession generally believe that alcohol is a poison, and as such produces its disturbance in the body; and consequently that no healthy, well-fed man requires or is better off for its use. So far all candid physicians and temperance workers can agree, but there is as yet an honest difference of opinion as to whether alcohol, like other poisonous drugs, has its rightful place among the physician's weapons for fighting disease. The experiment is being fairly tried in the temperance hospitals, in which diseases are being treated without the use of alcohol in any form whatever. What the final verdict will be it is too early yet to predict; but whatever that verdict may be, it is sure to confirm the statement that alcohol is at best a sharp and dangerous tool and never to be used indiscriminately, especially by those of a fine nervous organization. The more acute the nervous system, the greater the danger in using this seductive anæsthetic. Alcohol has some brief stimulant effect, but it is, in the main, an anæsthetic—that is, a drug which lessens sensibility.

One of the first effects of liquor is to make a man tingle pleasantly all over, or in other words it disturbs the innervation of the skin, and soon disturbs its sensibility, so that the drunken brute hardly knows when he is kicked and beaten. The evil effects of alcohol upon the muscles and germinal matter have elsewhere been spoken of, but the great danger of alcoholic liquors is the effect which they have upon the

nervous system and the inevitable loss of self-control which their free use entails. No well man ever needs alcohol in any form, and no sick one ought ever to have it except upon a doctor's prescription, and then only during his advice, and it is more than probable that both physician and patient would fare better without its use, except in very rare emergencies.

Bread and butter are far better food than any malt liquor, for the latter contains only part of the elements necessary to feed a man, all of which may be found in bread and butter. Add to this one eighth meat or cheese, and you have about the right proportions of the three classes of food, already described, to form a nutritious diet.

By nutritious food we mean it should contain those elements that are necessary to make up a healthy body, and a deficiency in any one of these will bring a correspondingly deficient body. Chemists tell us that there are fifteen of the elements found in the body, namely, oxygen, hydrogen, carbon, nitrogen, phosphorus, sulphur, fluorine, calcium, iron, manganese, silicon, etc., already given on page 73. Man cannot live on these crude elements any more than he could build a house of sand, clay, and water. He would starve to death if he were fed only on just so much of these crude materials as he has been in the habit of taking combined in his daily food; for none of the elements except oxygen and nitrogen are taken into the body in their free or uncombined condition. These gases (oxygen and nitrogen), as we know, supply the body with the air necessary for its ventilation and the destruction of its waste product; but they are not food in the sense in which we ordinarily employ the term, for food must be something more than a mere chemical compound. It must be toothsome as well as nutritious, and it must please the palate and the stomach, or the most scientifically constructed food in the world will not long nourish or satisfy a human being. And herein is the great fault of the most of patent infant foods; they are constructed on thoroughly scientific, but generally non-appetizing, principles. They

contain exactly the amount of carbon, nitrogen, silicon, and lime that the scientific infant ought to take for its proper nourishment and growth, but, unfortunately, the average human baby does not like the taste of them, and will have none of them, and the scientific physician, sooner or later, has to betake himself to old-fashioned milk or make out a death certificate. Nevertheless, it is most emphatically true that food, to be nutritious and sufficient, must contain all these elements in their proper proportion, or there will be a breaking down somewhere in the "body politic."

Less than two hundred years ago scurvy was one of the most dreaded diseases on all the ships in the then known world. Sailors, after being some time on shipboard, broke out with the most disgusting sores, their hair and teeth fell out, and their swollen and festering gums hardly enabled them to crunch the salt meat and stale biscuit that were their daily rations. Scurvy is simply the penalty of trying to live without fresh meat and vegetables; and so generally is this now known that it has become an almost unknown disease, for, by law, ship-owners are obliged to furnish their crew with the proper preventives.

Furthermore, food to be nutritious must not contain any dangerous ingredients added to it either by carelessness or fraud, the latter of which is one of the crying sins of these latter days. Hardly any thing that we eat, drink, or put on but is adulterated. In fact, if we believe half what the newspapers tell us, we take our lives in our hands every time that we sit at our dinner or breakfast table.

All flour, say the public analysts, is adulterated with alum and terra alba until eating it is scarcely more healthful than trying to digest powdered mill-stones, while the yeast or baking-powder with which it is raised is said to be a perfect chemist's shop of compounds improper to introduce into a human body. And then, as to butter, it is a fact that they turn out car-load after car-load of butter that is made in the packing-house, and not at the dairy. Pretty good butter it is too; far better than much of the cheap stuff that is

honestly and dirtily made from cows' milk; for properly prepared oleomargarine is a nutritious and healthful article of diet, and one that has done much to cheapen the poor man's breakfast table. And yet most of us honestly confess that we would rather know what we are eating; and it takes some little moral fortitude to use a butter that you know is made of beef suet. But it is not a dangerous substance, and it is so well made that the best expert on the subject of butter in the city of Chicago was deluded into buying a pail of pure oleomargarine for his family use, and eating it too. On the whole, we may count ourselves fortunate if we only find oleomargarine in the way of adulteration in our butter; for in these latter days they have found ways of bleaching and disinfecting even the most rancid and unpalatable butter so that it may be put upon the market with any color, odor, or taste desired; but all such processes are dangerous and hurtful to the consumer.

Meat, fortunately, cannot be adulterated, but they do say that one of the largest packing firms in a modern Sodom utilizes for its canned meats such scraps and refuse as they cannot sell even to a Chicago boarding-house. Meat may be diseased by long standing, and produce within itself alkaloids that are hardly less poisonous than strychnia. This is apt to happen in corning beef, when it is imperfectly cured, so that every once in a while we read of epidemics of poisoning that have followed the use of tainted meats. Uncooked sausages, leberwurst, etc., are especially prone to such changes in warm climates; and in fact uncooked or partially cooked meat never should be used, except by the advice of a physician, for in this way tape-worms and trichina are introduced into the system.

Our potatoes, perhaps, are safe, for no man has yet discovered a method of profitably making an artificial potato, though there was an enterprising genius that last winter put upon the New York market an artificial egg that had not the most distant acquaintance with a hen. Its shell was made of plaster of Paris, the white of blood albumen, and

the yelk of some unknown compound, and the whole was so cleverly put together that thousands of them were sold when eggs were highest, before the fraud was suspected. Condensed eggs, as they are called, are largely adulterated with blood albumen and colored with chromate of lead, so that instead of being, like eggs, a proper, nutritious, and convenient article of food, they are dangerous and poisonous. Several cases of poisoning from lemon pies made with these condensed eggs are reported, and therefore desiccated eggs should be relegated to the oblivion they deserve.

Bishop Asbury was in the habit of telling his young preachers, when they grumbled over the uncleanliness of the tables they were forced to put up with, that "a baked potato and a hard-boiled egg are always clean and nutritious articles of diet;" but that was before the days of these artificial eggs and Saratoga chip potatoes, which are sometimes prepared, as we are told, from the refuse of the larger hotels North, and shipped abroad in neat boxes for foreign consumption only.

Suppose we turn in despair to our cup of coffee. We may not find it much better, for the fact is that latterly not more than one woman in a thousand knows how to make a good cup of coffee. When you find the rare thousandth woman, she cannot do it unless she is furnished coffee to make it with, and I presume that a good three quarters of all the coffee on the market is so largely adulterated that it would take a competent chemist to find the percentage of coffee contained in it. It was once thought that buying the unbrowned coffee-berry you were sure to get a pure article, but in these latter days the sons of Belial have contrived imitations in plaster of Paris that would deceive the very elect, in color, form, and every thing but taste. When it comes to browning the berry, some Yankee has found that the cheap and nutritious peanut can be browned to exactly the same tint as the coffee bean, which, when split, it closely resembles, and can be put upon the market at a far less price. It is said, furthermore, not to have the bad

effect of wakefulness that belongs to the unadulterated coffee; and the same may be said of chicory coffee, rye coffee, potato paring coffee, and all the endless variety of adulterations that the high price of coffee has forced upon the market; and, worst of all, there seems at present to be no satisfactory method of recognizing these adulterations except the microscope in the hands of an expert.

Sugar has fared almost as badly in the contest between honesty and illegitimate profits, for sugar is sold in the markets at a less price than it can be honestly manufactured from sugar-cane. Whole cargoes of white earth are brought from Chili for this purpose, and car-load after car-load of corn is worked up into glucose to adulterate syrup and molasses, to say nothing of the more dangerous use of poisonous salts of tin that are used in making what is known as new process sugar. And so the list might be almost indefinitely prolonged; and yet after all most of us are more frightened than hurt by these adulterations of food. They are a crying evil which needs the appointment of a State chemist, and heavy penalties for any contamination of food either from carelessness or fraud. But as yet the staple articles of food in this country are good and cheap. The per diem cost of honestly feeding an inmate of our State institutions is from fifteen to twenty-five cents. Atkinson, in a recent article on the subject of food, estimates that twenty-four cents daily is sufficient to feed an adult in this country, divided as follows:

Meat, ½ lb.	10 cents.	Sugar and syrup	2 cents.
Eggs	5 "	Tea and coffee	1 "
Bread, ½ lb	2½ "	Salt, spices, etc.	1½ "
Milk, ½ pint	5 "		—
Vegetables	2½ "	Total	24 cents.

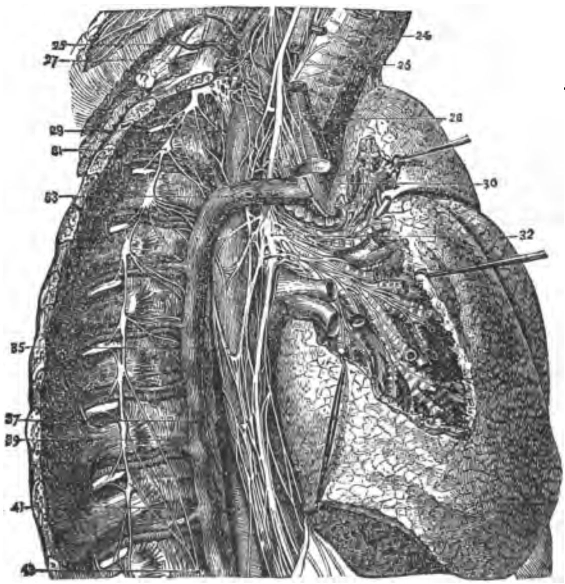
So that for less than a quarter of a dollar daily the machinery may be run and the waste repaired of the houses in which we live, for, as says another, "man, in a strictly materialistic point of view, is an engine, fire-box, boiler, and fuel complete. The carbonaceous foods are the fuel, and muscular contraction and heat are the power and results produced

by its combustion. This combustion of food is not accompanied with flame, but its results are none the less real in the way of heat and carbon dioxide gas which is produced whenever carbon is burned, whether inside or outside of the body. Between 1,200 and 1,300 grains of this gas, according to Huxley, are given off daily from the body; but as we do not eat charcoal directly this gas must be formed from the carbon in our food, in which form we consume nearly seven ounces of charcoal daily. A white spongy loaf little resembles black, brittle charcoal, but the loaf may easily be converted into the latter by simply letting it bake at a high enough temperature to drive off all of the water of the dough and leave its carbon only behind as a crisp, brittle mass, no longer fit for eating, but excellent for burning and keeping indefinitely unless put in the fire. In fact, pure carbon is, except by heat, one of the most unalterable things in the world. That is why the loaves of bread baked in Pompeii more than eighteen hundred years ago may be seen to-day in the museum at Naples, carbonized like charcoal, and hence almost indestructible. They will show you in Zürich blackened wheat, burned, long before the destruction of Pompeii, in one of their Swiss lake villages built on piles over the water. Possibly the whole village was consumed at the same time; but, be that as it may, these blackened bits of grain, mixed with similarly carbonized domestic utensils, have been preserved under the waters of the lake hundreds and hundreds of years unchanged, for carbon under such circumstances is one of the most unchangeable of all substances. And fortunately it is so, for otherwise in course of time the letters in our books would have all faded away and Birmingham and its coal mines disappeared in thin air.

But unchanging as is carbon outside of the body, except at a heat higher than the thermometer measures in the mouth, somehow these carbonaceous foods are oxidized within us just rapidly enough neither to burn us to a fever nor, in health; ever to leave us uncomfortably cool. We have for the house

in which we live a perfectly regulated automatic furnace and engine which runs our machinery by burning the refuse of the body, something as the engine at a saw-mill is run by burning the useless slabs. If now these slabs should take fire and spread to the rest of the mill we have a fair comparison of fever, which is an ungoverned combustion, beyond the control of the inhabitant of the house. Often he is to blame for the accumulation of refuse in the house, to remove which fever comes, but the conflagration once under way he is powerless to stay it, for the heat-regulating center, according to H. C. Wood, is located in the brain, but is entirely involuntary in its action. In fact, the physiologists are finding altogether too many of these nerve-centers for the comfort of the ordinary student of physiology, and, worse than all, they are burdening them with such names as thermogenetic and thermolytic, meaning by the former heat-producing and by the latter heat-discharging. They have also coined another word, thermotaxy, which is used to express the adjustment of heat within the body. "The temperature of the body," says Dr. Macalister in the last Croonian Lectures, "is due to the action of a heat-generating mechanism in the body, the chief source of heat being changes in the muscles. The loss of heat is controlled by a heat-losing mechanism, mainly associated with vaso-motor and respiratory activity. The balance between heat-production and heat-loss is maintained by a heat-adjusting apparatus. The three mechanisms are successively evolved as we ascend in the animal scale. Cold-blooded animals have little more than a thermolytic or heat-losing mechanism. Infants have only the thermogenetic and thermolytic, there being hardly any adjusting mechanism, as is shown by the instability of their temperature. Fever is a dissolution process—the last mechanism evolved, the thermotaxic, gives way first, then the thermogenetic, and lastly the thermolytic. Or, in plainer English, the heat engine loses its governor and runs wild. Conversely, when the patient convalesces thermolysis is first restored to normal, then thermogenesis, then thermotaxy." Warming the body is a more

complex process than it was once supposed, for it requires other and more delicate adjustments than simply swallowing so much food like shoveling coal into a furnace. Fortunately these adjustments are beyond our powers, or we should burn up from carelessness or freeze o' nights. Heat, like life, is above food, and science reiterates the biblical advice to take no "worry" over what we shall eat and what we shall drink, for if we follow the teachings of common sense we will eat sufficient nutritious and properly cooked food. "O fool, do not gormandize, neither stint yourself to a scanty allowance. Nature will see to it that the body is kept in repair, and that fuel sufficient to supply its engines will be absorbed, if you but follow her dictates."

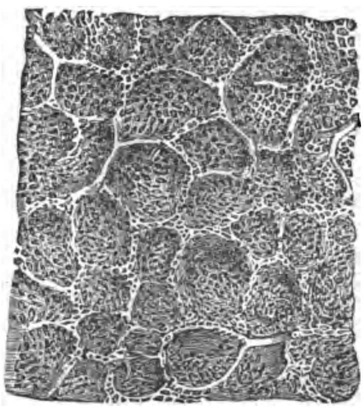


Sympathetic Ganglia and Large Vessels of the Chest.

CHAPTER IV.

THE WHEEL AT THE CISTERN.

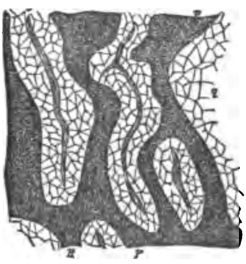
IN Chapter III the preparation of food in the twenty odd feet of kitchen with its four million cooks has been described. But the best cooked food must be eaten promptly or it becomes worse than useless; hence arrangements have been made to deliver that for the body, after it has been properly prepared, in the fraction of a minute. The agents by which it is accomplished are the villi of the intestines, the lymphatics, and the heart, with its arteries and veins. The chyme, already described (see page 81), after its preparation for food, is taken by a multitude of tiny absorbents which line the intestinal walls. Though they are identical with the lymphatics, hereafter to be described, they are called lacteals, for the reason that when they are filled with absorbed chyme, now called chyle, they appear as if filled with milk (*lac*, in Latin). These lacteals soon unite to form larger trunks, which increase in size by aggregation until they unite to form a vessel about the size of a goose quill, known as the thoracic duct, which runs along the spinal column and at last empties its contents into the venous circulation, near the junction of the left jugular and subclavian veins (see page 93), whence the chyle and lymph, which have been added to it, are carried



Absorbents of the Colon.

with the blood the round of its circulation. Lymph is chemically the same as blood serum, and circulates throughout the body through what are known as lymph-vessels, or the lymphatic system of vessels. These are exceedingly delicate tubes, whose coats are so thin that the fluid they contain can be readily seen through their walls. The lymphatics are the general absorbents of the body. The lacteals are the lymphatics whose especial duty is to take up the digested food from the intestine, for lacteals and lymphatics are identical in structure. All parts of the body which are supplied with capillary blood-vessels are also supplied with lymphatics, which are so numerous that could they be injected with quicksilver the surface of the body would appear like a mirror. Lymphatics also originate from the inner surfaces of all of the cavities of the body and most of its organs, except brain substance, the spinal cord, cartilage, tendons, nails, and hairs, which are destitute of lymphatic vessels and glands.

The lymphatic glands are small, oval bodies, varying in size from a small pea to an almond, located along the tract of the lymphatic vessels. In fact, the lymphatic vessels pass directly through these lymphatic glands, which act apparently as filters for the lymph as it passes through them. As may be seen by the cut, they are admirably arranged for this purpose, the multitude of their divisions (*trabeculæ*) necessitating a slow flow and an efficient straining of the lymph as it passes through. The lymphatic glands are numerous in the mesentery, groin, axilla, and neck, where they are especially prone to enlarge. What are familiarly known as "kernels," are these lymphatic glands engorged with foreign matters. If there is a sufficient quantity of this to set up inflammation in the gland, it becomes enlarged, red, and tender, and may go on to form an abscess. If the enlargement is less, the gland may simply remain



Section through the Medulla of a Lymphatic Gland. —*Klein.*

swollen, distinctly visible, and unless properly treated may continue in this condition for years, giving rise to what is known as scrofula (literally, pig-neck). Physicians are not yet agreed as to the cause of scrofula, but, what is more important, generally agree that scrofula can be cured, provided it be taken in hand sufficiently early. Enlarged glands about the neck—except those following diphtheria or scarlet-fever—should always be considered of sufficient importance to require medical advice; for these enlarged glands are usually the forerunners of other scrofulous manifestations. In Part II may be found some general directions for the care of those thus affected, which, if properly followed, will more than repay all time thus given, for old scrofulous ulcers and fistulæ are among the most persistent and annoying of ailments.

The lymphatic fluid, so named from its resemblance to water (*lympha*), circulates, or, more properly, percolates, through all the tissues of the body, by means of an interminable network of lymphatics, and the perivascular spaces. Thus all of the body is supplied both with blood and lymph by means of the two circulatory systems of the body; namely, the lymphatic and the sanguinous, or that containing the blood. The lymphatics differ from arteries and veins in that the latter unite to form trunks of increasing size, whereas the lymphatics pursue, as it were, an independent course, not enlarging much in diameter, though they freely communicate with each other. Moreover, the fluid which is constantly passing through the veins performs its circuit under the impulse of the heart's action, while the lymphatic fluid is propelled solely by the action of the walls of the lymphatic vessels, whose exact action is not yet definitely understood. The structure of these lymphatic vessels is not unlike that of the smaller veins, except that the lymphatics are more delicate and transparent, though their two coats may be recognized, and in the case of the thoracic duct separated.

As may be inferred from what has previously been said in regard to the circulation of lymph, the lymphatic vessels

have a propulsive power of their own, the absorbents having been seen to contract and propel their contents with considerable power, independent of pressure or motion communicated from other parts of the body; and this motion is aided by the presence of valves in the course of the lymphatics, one or two always being found where the absorbents open into the veins, to prevent regurgitation of blood.

There is much yet to be learned concerning the lymphatics and their contents; but we may summarize our present knowledge as follows:

Chyle is the fluid contained in the lacteals or the lymphatics of the intestines. This fluid is transparent after fasting, but milky during digestion, owing to the presence of minute particles of fat. Chyle taken from the thoracic duct is distinctly yellowish or pinky white in color, with a salty taste; and after its removal from the body forms a pinkish white clot, from which an opalescent fluid is squeezed out as the clot grows firmer.

Lymph differs from chyle in that the former contains no fat, but is a watery fluid containing what are known as lymph corpuscles, which are probably identical with the colorless blood corpuscles. In fact, some believe that these corpuscles are formed during the passage of lymph through its vessels. In short we find:

1. That lymph and chyle are substantially alike, except that chyle contains fat, and lymph none, or nearly none.

2. Lymph and chyle are substantially like blood, the difference being only one of degree. In fact, these liquids are possibly rudimental blood, containing corpuscles in process of development into red corpuscles. The difference between the lymph and chyle and the blood becomes less and less as the two former pass through the thoracic duct, or, in other words, as they approach the place where they are to be mingled with the blood.

3. Blood, lymph and chyle agree in that they contain fibrine and coagulate spontaneously, although the clot of lymph and chyle is softer than that of blood. In this prop-

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erty of spontaneous coagulation they differ from all other animal fluids.

What is coagulation? A Latin term for the process of clotting; a phenomenon that, fortunately for us, occurs in the blood whenever it is exposed to the air. In the days when bleeding was part of the treatment for almost every disease great stress was laid upon the appearance of the blood clot which formed in the basin wherein the blood was caught. Latterly it has been learned that the appearance of the clot is largely due to the amount of fibrine it contains, and that the coagulation of the blood depends upon the fibrine found there, or, more properly, formed there; for there is reason to believe that fibrine does not exist as such in the blood, but is formed by a chemical reaction between substances found in the blood plasma and blood serum.

The difference between these two fluids is this: blood plasma is the fluid in which the corpuscles, hereafter to be described, float, while blood serum is the fluid which separates from clotted blood upon standing; or blood serum is blood minus the clot, or blood plasma minus its fibrine, if we accept the former idea that fibrine is held in solution in the watery part of the blood. Fibrine can readily be obtained in long threads by whipping fresh blood with twigs, but the latest teaching on the subject is that it is not held in solution, or only in part. It is now supposed that during the whipping fibrine is formed by the reaction of two other substances (fibrino-plastin and fibrinogen). One of these can be readily obtained from any serous exudate of the body, and can be kept indefinitely without coagulation unless blood serum be added to it, when clotting immediately takes place.

Thus it seems proven that the coagulation of the blood and the formation of fibrine are caused primarily by the interaction of two substances (or two modifications of the same substance), fibrino-plasters and *fibrinogen,* the former of which exists in the serum of the blood and in some tissues of the body; while the latter is known at the present only in the

plasma of the blood, of the lymph and of the chyle, and fluids derived from them.

Fibrine is insoluble in water, alcohol, and ether, soluble in dilute alkalies forming albuminates. When digested with a two per cent. solution of muriatic acid, fibrine is transformed into a semi-transparent, jelly-like mass. By the action of gastric juice, fibrine is converted into peptone, the change being a chemical one and not one of simple solution. If the gastric juice contains but little pepsin the products of the digestion of fibrine with this fluid will be precipitated by neutralizing the solution. By the action of pancreatic juice fibrine is transformed into peptone, for which see Chapter III. But however formed, or digested, fibrine is the most important element found in the blood, as regards the preservation of life. If it were not for this substance, in the blood or formed from it, the slightest nick into a blood-vessel would necessarily cause death; for the only reason that blood ever ceases to flow from such an opening is that the passage of the blood over the edges of the artery causes a clot of blood and fibrine in the wound and thus stanches the flow. Later the coloring matter of the blood-clot is taken up, and the fibrine becomes organized, as it is called, or so like natural tissue that it can indefinitely serve in its stead, and thus the gap is permanently filled. Occasionally we find persons in whom the process is imperfectly performed, and hence they are known as bleeders, because the slightest wound becomes a grave source of danger from their inability to check the bleeding originating therefrom. As trivial a matter as drawing a tooth may cost such a bleeder his life, for the oozing may persist from the tooth socket until death ensues from exhaustion. The late Duke of Albany died from a like trivial accident, for he was one of those in whom a scratch is a serious event, and so would it be with all of us if it were not for this property of spontaneous coagulation in blood exposed to the air. Blood will also coagulate within the veins after death, but this takes place more slowly than in blood drawn from the body. When from any reason the

fibrine contracts less rapidly than usual, a white layer forms on the surface of the clot, consisting of fibrine and white corpuscles, forming what is known as the buffy coat. This buffy coat contracts more rapidly than the rest of the clot, so that a cup-like depression is found on the surface of the clot, which is then said to be cupped. These coagulatory changes are hastened by a variety of circumstances, among the more important of which are:

Sex. Women's blood coagulates more rapidly than the blood of men, but the clot is less firm. Embryonic blood coagulates imperfectly. Arterial blood coagulates more rapidly than venous.

A warmth of 100 to 120 degrees F. (37.8 to 48.9 degrees C.) promotes coagulation. A higher temperature than this retards it, while a temperature of 200 degrees F. (93.3 degrees C.) stops coagulation altogether, even after the blood has been cooled. Conversely, a cold of 40 degrees F. (4.5 degrees C.) entirely stops coagulation; but coagulation will, under these circumstances, take place as well as ever after the normal temperature of the blood has been restored.

Motion retards coagulation, but rest promotes it.

The *multiplication of points of contact* promotes coagulation. Thus we whip blood with a bundle of twigs to coagulate the fibrine. Or, again, the blood coagulates more rapidly in the rough cavities of the heart than in the smooth veins and arteries. Conversely, coagulation is *retarded* by a variety of circumstances, some of which have already been mentioned, among which are:

(*a*) *Cold*, which, according to some experimenters, if sufficient, entirely prevents.

(*b*) *The addition of soluble matter to the blood.* Many saline substances, and more especially sulphate of soda and common salt, the alkaline hydrates, carbonates, and acetates dissolved in the blood in sufficient quantity, prevent its coagulation; but coagulation sets in when water is added so as to dilute the saline solution. The same is true of dilute acids, potassic and calcic nitrates, and ammonia chloride.

(*c*) *Contact with living tissue* retards coagulation, while contact with dead or foreign tissue favors it. Thus we pass a thread through an aneurism to form a nucleus for coagulation and to assist the cure. Blood drawn into a basin begins to coagulate where it touches the sides of the basin, and a wire acts like a thread in an aneurism.

(*d*) *Large dilution* with water retards, if the quantity used is greater than twice the bulk of the blood.

(*e*) *Exclusion of air* retards, and certain gases apparently prevent entirely coagulation of the blood.

(*f*) *The mode of death.* Thus in death by asphyxia, where the blood is imperfectly aerated, coagulation is retarded. According to Hunter, the same result occurs in death from lightning, blows on the stomach, over-exertion, fits of anger.

Some little space has been given to the matter of the coagulation of the blood for the reason that the explanation of coagulation in many of our text-books is imperfect, and secondly because we have no more striking instance of Almighty foresight than the formation of these tiny white threads in freshly flowing blood. These soft curly bits seem a very inefficient means to stay an alarming hemorrhage, but feeble as they appear they are the threads upon which life literally hangs, for science knows no means by which bleeding can be permanently arrested without the aid of these threads of fibrine. Fibrine and coagulable lymph, which is nearly the same thing, are nature's carpenters and joiners to repair the breaks made in the house in which we live, which, without their aid, would become too dilapidated for habitation before its occupant had passed through childhood. No other article of dress wears half so long or well as the body, for none other of our clothes can repair themselves as does this house of clay. Let us look for a moment at how this is done.

The best thing that can happen to a wound is to have it heal, as the surgeons say, by first intention, that is, that its edges shall immediately grow together after the bleeding has been checked. The arrest of bleeding is due, as has already been

said, to the formation of a clot in the rough edges of the cut blood-vessels, whose inner coat is elastic, and retracts so as to form an edge for the formation of a clot. This acts as a plug within the bleeding vessel, if not too large, and thus stops the hemorrhage. If now the edges of the wound can be accurately brought together, in the course of an hour or two they become reddened and slightly swollen. This swelling is due to an interference in the circulation of blood in the part, which causes the exudation of plastic material through the walls of the blood-vessels—to be described later in this chapter. This plastic material is like the temporary callus, described in connection with broken bones (see Chapter II), and like it glues together the sides of the wound, provided there is no foreign substance to interfere and the edges of the wound have not been bruised or otherwise injured. This is the result which every surgeon hopes to obtain when he carefully cleanses and stitches together the edges of a fresh cut, whether made by himself or accident. Sometimes the process is so perfect that there is absolutely no scar, but more frequently a narrow white line can be seen after adhesion has taken place. This whiteness is due to a destruction of the skin—as is seen also in the pits of small-pox; for true skin is never reproduced, but the gap filled in as best it may be with plastic lymph, which at first is soft and sticky as fresh glue, but later hardens into a tough white substance, known as cicatrix, the Latin name for scar. Much else of the body is replaced every few months, but a cicatrix is unchangeable, for it contains no germinal matter—and hence remains as more or less of a deformity during life. But a scar is better than a gaping wound, and is the best result that can be hoped from a large wound, or an extensive burn, for if repair does not take place in this way the only thing that can then be done is to trust to the slower process of union by granulation. This is what usually happens after serious burns, or extensive injuries, where the edges of the wound are too far separated to be glued together by plastic lymph. In these cases we find the swelling about the neigh-

boring blood-vessels so great that not only plastic lymph escapes through their walls, but also the lymph, blood and pus corpuscles. Or in other words the wound is said to maturate and discharge pus. Beneath this pus, granulations—"proud flesh"—form in the shape of rosy red mounds that endeavor by their rapid growth to fill up the gap, until on a level with the surrounding skin, which it at last unites by a cicatrix, exactly as in the case of union by first intention. At least that is what is sought to be done, but sometimes the strength of the patient gives out before the process is completed, either from a too profuse discharge of pus, or too great inflammation. And what is this inflammation so greatly dreaded in a wound? Inflammation, according to our present theories, is a conflict between the white blood corpuscles and minute forms of life, so tiny that they cannot be seen except through a microscope. These beings are known as microbes, and will be more fully described in Chapter VIII; for the present it is sufficient to remember that they lodge and grow in every fresh cut. Their presence there produces the heat, pain, and swelling of an inflaming wound, in which the white blood corpuscles are doing their utmost to overwhelm these invaders. Inflammation then is, as Mr. Sutton well puts it, "a battle between the microbes and the white blood corpuscles; the latter are the defending army, whose roads and base of supplies are the blood-vessels." Recent experiments seem to show that the method adopted by the white blood corpuscle to dispose of its adversary is to envelope the attacking microbe and devour it. These devouring white corpuscles constitute the pus or matter so freely discharged from an inflamed wound.

There is no more wonderful thing in our wonderful bodies than these same white corpuscles, or leucocytes, as they are sometimes called. Twenty-five hundred of them must be laid in a line together before they measure an inch, but they are undoubtedly the most truly vital parts of our bodies. These bits of colorless matter, which occupy only one twenty-five-hundredth of an inch in diameter each, are in incessant

movement, not only from their being carried forward by the current of the blood, but from independent motion of their

Leucocytes.

own. When watched beneath the microscope they slowly writhe and twist like an impatient school-boy kept in after school. The cut well shows these changes of form, which occur from movements in every part of the white corpuscle, contracting and dilating, like one of the lower forms of organisms (amœba) which are found in stagnant water.

While living and moving the structure of the white corpuscles can be ascertained with difficulty, if at all; but by largely diluting blood with water or weak acetic acid the vitality of these moving bodies is destroyed and they swell up, and now they are seen to be roundish sacks with very thin walls which hold within them a colorless fluid containing more or less granular matter, which is gathered together in an irregular form in the center. Huxley believes this central body is the red corpuscle, hereafter to be described, which is set free by the bursting of the sack of the white corpuscle.

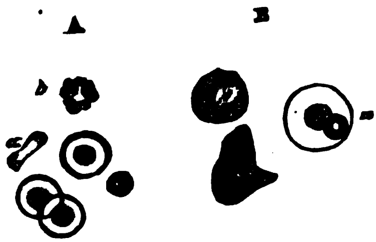
Whether these white corpuscles bear this relation to the red corpuscles is still under dispute. Dalton thinks there is no evidence of any transformation of the white corpuscles into the red either in man or the lower animals, while Huxley, as we have seen, inclines to the belief that "the red corpuscle is simply the nucleus of the colorless corpuscle somewhat enlarged, flattened from side to side, changed by the development within itself of a red coloring matter. . . . In other words, the red corpuscle is a nucleus free." Others believe the red originate in the spleen, and others think the red marrow of the bones converts protoplasmic marrow cells into red corpuscles. Nor do we know much more about the

origin of the white corpuscles except that they possibly begin their existence as the lymph corpuscles already described. Where then the white corpuscle originates, or whither it is going, we know but little more than that it is a form of germinal matter, vital, moving, vigilant to beat back the invisible foes with which the body is constantly assailed, and possibly performing other duties as well.

According to Klein, some of these white corpuscles are stationed in the lymphatic glands, where they lie in wait in their meshes to devour inflammatory and other products as they are caught in the filters, but the bulk of these colorless corpuscles are constantly wheeling to and fro, backward and forward, through the blood-vessels, as it was once thought, aimlessly; but, if we accept Metshnikoff's theories, they are under arms to repel bacterial invaders. This observer has carefully studied the behavior of certain of the bacteria in the blood of the lower animals. Where it was found these animals were not susceptible to the diseases caused by bacteria, it was found that the white corpuscles enveloped these lower forms of life within themselves, and thus prevented their multiplication, but when the white corpuscles failed to do this the animal experienced the disease in all its virulence. If this holds true for man, our health and life even hang on these invisible squirming points of matter far more than it pleases our pride to think. They are our Swiss body-guards, whose ceaseless vigilance makes life possible, by giving up their lives in the defense of the house in which we live.

But the blood has other duties than simply to patch a flaw and beat back bacterial invaders. The crimson color, greasy feel, and characteristic odor of fresh blood are known to all, but few have any just idea of what an exceedingly complex compound blood really is. "Red as blood" is one of the oldest of similes, but the microscope shows us that blood is in reality not red, but a colorless fluid in which float an innumerable number of amber disks, which, when gathered together in mass, give blood its color. This color varies with the

source from which the blood is obtained, for blood spurting from an artery is florid red, while that which flows from an opened vein is purplish in tint. This variation in color is due to changes in each of the red corpuscles, whose numbers are almost inconceivable, for a cubic inch of blood contains seventy times as many red corpuscles as the world does inhabitants. Nevertheless, each of these is well worth our careful study beneath the microscope, where it must be made; for the red corpuscles are even smaller (one thirty-two-hundredths of an inch) than the white. But they are no less important to the body, for if the white corpuscles may be likened to body-guards, red corpuscles are liveried servants, ceaselessly hurrying to and fro to feed the germinal matter of the body.



CORPUSCLES OF HUMAN BLOOD.
(Magnified about 600 diameters.)

A. Red corpuscles: *a*, a corpuscle seen edgeways; *b*, a corpuscle in an altered state, arising from pressure. A small spheroidal red corpuscle, such as may be frequently met with in the blood, is represented beside the larger discoidal ones.

B. Colorless corpuscles: *a*, a colorless corpuscle acted upon by diluted acetic acid, showing its nucleus.

The French call the blood "running flesh," and aptly; for flesh or muscle is made up of a multitude of stationary, waiting servants. In the blood we find the corpuscles taking the place of the muscular stria, or checkers, already described. These blood corpuscles are the waiters in this hotel in which we live, and they are kept exceedingly busy, for they are only given about two minutes to make their entire round. They start out from the lungs, as we shall hereafter see, very ruddy and jolly from their draughts of fresh air, but as they hurry onward, exchanging their surplus oxygen for refuse carbonic dioxide, they at last become blue and overloaded, and finally stagger into the air-cells of the lungs, just in time to save themselves and us from death by asphyxia. So accurately is the whole matter arranged that a few minutes'

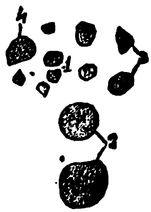
delay anywhere along the line is matter of serious importance to all concerned. This change in the color of the blood can be readily shown by winding several turns of twine tightly about the root of a finger. In a few seconds it loses its rosy tint and becomes dusky and swollen. If the experiment is persisted in long enough, and the twine tightly enough wound, the finger may actually mortify, or die from lack of blood, or rather lack of aerated blood, for no other will feed and keep alive germinal matter. Aerated blood, then, differs from blue blood in that the red corpuscles of the former contain oxygen, and in the latter the oxygen is largely replaced by carbon dioxide gas, which changes the tint of the red corpuscle from amber to blue, owing to the effect that these gases produce upon one of the constituents (hæmoglobin) of the red corpuscle. Hæmoglobin is an iron compound, of which there is said to be enough in the blood to enable a sentimental Frenchman to make a mourning iron finger-ring from the blood of his friend. Hæmoglobin is the most important chemical constituent of the red corpuscles of the higher animals, for in man, the dog, pig, and ox, the red corpuscles are almost entirely pure hæmoglobin, and in fact, solution of hæmoglobin behaves almost exactly like blood in regard to its change of color with various gases. A watery solution of hæmoglobin has the bright red color of arterial blood, and like it contains oxygen, so loosely held in combination that it can be removed by an air-pump. If a current of nitrogen, hydrogen, or carbon dioxide gas is sent through a solution of hæmoglobin it loses its bright red color and takes on the hue of venous blood. If now this solution of hæmoglobin be shaken with the air, oxygen is absorbed and the solution again becomes bright red, and the change may be indefinitely repeated. So then we conclude that the change in the color of the blood corpuscles is not due to their change in form, as was once taught, but is dependent on the relative oxidation of its hæmoglobin, or blood-coloring matter. Thus, in arterial blood the hæmoglobin is oxidized and of a scarlet color, while in venous blood a part of the hæmoglobin is deoxidized and

of a purple color. Possibly the physical condition of the corpuscles, and also the presence of carbonic acid, may be elements in the case; nevertheless, there can be but little doubt that the change of color is primarily, if not entirely, due to the oxidation and deoxidation of the hæmoglobin.

To recapitulate, the blood is to the naked eye a crimson-red fluid, but under the microscope it is found to be in reality a colorless fluid in which float a multitude of minute bodies, to which the name of corpuscles has been given. These are of various sizes and shapes, the largest (one twenty-five-hundredths of an inch), being known as white or colorless corpuscles. These are probably identical with lymph and pus corpuscles, whose functions have already been described. The red corpuscles are the oxygen carriers for the body, and are more numerous and smaller than the white corpuscles. The red corpuscles make up about one half of the bulk of the blood, and in shape closely resemble a microscopic muffin —and a heavy one at that, for its top and bottom are sunken so as to make the edge of the muffin biconcave; hence when viewed edgewise they appear as rods with slightly expanded ends. Their transverse diameter is from one three-thousandth to one thirty-two-hundredth of an inch, and their consistence apparently about that of a stiff jelly, for if watched beneath the microscope the red corpuscles are found first to fluctuate and then to arrange themselves in piles, like rouleaux of coin, adhering to each other by their broad surfaces, very likely from the coagulation, already described, taking place in the blood. Great dilution of the blood causes the red corpuscles to swell, and solutions of certain salts cause them to lose their smooth outlines and become irregular or crenated, and still further shrinking causes them to become covered with minute projections something like a horse-chestnut.

What are known as Norris's third or invisible corpuscles are probably simply discolored red corpuscles; but others which have been described as hæmatoblasts deserve a little further attention. These hæmatoblasts are granular matter more or less oval in form, paler, and about one third to one

half the size of the red blood corpuscle, and are always found in the blood of man and mammals. By many they are regarded simply as granular debris carried along by the circulation; but by others (Hayem, Osler, Kemp) are thought to be elementary red corpuscles or intermediate forms in their development. Recently they have been called blood plaques, or plates, a term worth preserving for the sake of clearly distinguishing them from the other varieties of corpuscles found in the blood. These plaques are composed of smooth, structureless protoplasm, but whether with or without a nucleus is not yet determined; and they have a remarkable tendency to adhere to one another and adjacent objects when removed from the blood-vessels.



1. Blood plaques, colorless and varying a little in size. 2. Microcytes of a deep red color. 3. Two ordinary red corpuscles. 4. A solid translucent, lymphoid cell or free nucleus.

The origin of these blood plaques is still a matter of dispute, for they are variously regarded as young red blood corpuscles; as derived from the red corpuscles; as derived from the white corpuscles; as nuclei floating free in the blood; as fibrin, and, finally, as independent elements. It seems scarcely worth while to mention the evidence upon which these views have been founded. Suffice it to say that all have been carefully examined by Kemp, and sufficient evidence brought against all other theories to render them most improbable, except the one that considers the third corpuscles as hæmatoblasts, or young red corpuscles. That they are not due to changes produced in other elements after the blood is drawn is shown by pricking the finger under osmic acid, which coagulates all of the other elements of the blood as they leave the blood-vessel and still these blood plaques may be shown in the fluid. Furthermore, we could scarcely ask for more conclusive proof than that five competent observers have seen them circulating in the vessels of the mesentery and in the uninjured vessels of the connective tissue of young rats. Kemp's opinion is that they are bi-concave, like the red corpuscles, and that they are in all probability

incipient red corpuscles. If so, we are a step nearer their origin; but we have yet much to learn concerning all of the various corpuscles found in the blood.

There is a time before birth when all of the corpuscles of the blood are white, gradually becoming mingled with the red also. Later in life the red marrow of the bones gives birth to marrow cells which are apparently converted into red corpuscles, which some think are again destroyed in the spleen; others that they are formed there as well.

This, then, is about the sum of our knowledge concerning the origin and end of the red corpuscles, which give to blood its vitalizing power; for science and Moses unite in declaring that "blood is the life," and that our well-being and comfort depend more largely upon its composition than on that of any other fluid of the body. Excess of red blood corpuscles produces vertigo, plethora, and headache; deficiency, anæmia, pallor, and the listlessness so common to the school-girl of to-day. Pie, cake, the piano, and the bad air of a modern school-room are poor materials out of which to make good blood; and good blood is essential to health and happiness. Better fewer books, better less company, better less culture, better less almost every thing, than to start into life such wretched apologies for womanhood as are too many of our high-school graduates. It is too high a price to pay for our modern civilization; one that is too dearly bought even at the return of an occasional Jex Blake or a Frances Willard. As a rule it is bad living rather than mental overwork that is to blame for this condition of affairs; for bad air, bad houses, and improper food will ruin the best animal, and it must be remembered that a part of us is as truly animal as the beasts that are nightly tied up within their stalls. There is an efficient society for the prevention of cruelty to animals; but there seems to be no Henry Bergh to interfere when a growing child abuses the animal body that is of infinitely more value to the world than many horses. Moreover, custom and fashion have so contrived to hem in a growing girl that she cannot get a fair chance for a sound body without

a life-long struggle with the community. "The natural destination of the woman over thirty," says Mr. William Blaikie, "is the sofa, a shawl, and the neuralgia. And why? Because until recently the modern girl was brought up in such a way that the brain is developed at the expense of her red blood corpuscles, and she comes to womanhood a bundle of nerves and physical degeneration. A girl has as good a claim to strength and health as a boy, and in general needs them more; but she can acquire them in no other way than he does, namely, by systematic exercise. A daily half hour's recess, or even Saturday's shopping, cannot supply this, and it is especially for the growing school-girl and the woman of sedentary life that there can be found in Part II practical hints for physical culture, carefully prepared by one who has devoted his life to the work. Johns Hopkins University and a few of the more advanced of our female seminaries of this country have efficient classes in physical culture for young ladies; but such institutions are lamentably few and far between. A college class, however, is not necessary for this purpose. A little very simple apparatus, and determination and perseverance in its use for only a few minutes daily, would transform many a listless being into "a queen and sister of the gods." Tennis, croquet, boating, skating, fencing, tricycling, and horse-back riding are all good, and if regularly practiced may be substituted for the exercises detailed in Part II when possible. Where these for any reason are impossible, walking ought to be substituted. "Every girl blessed with moderately good health can walk a mile or two every day and feel the better for it." The more confining and monotonous one's employment the greater the need for daily systematic exercise, and, as Blaikie well says, no one can be so crowded with work that he will not be the better for a short walk before retiring; and the greater the pressure of other duties the greater and more pressing the need for just this outing. It requires no little resolution and self-control to force tired and unwilling feet from a comfortable seat and a cozy fireside; but unless this is done daily, at

some present inconvenience, the muscles grow soft and flabby, and the body becomes clogged with refuse.

Fashion once in a while stumbles upon a sensible fad, and just now it is walking clubs for young girls. "The magnificent girl," says the New York *News*, "who swings along at a four-mile gait is not only a subject for reflection, but a theme for admiration, congratulation, and tenderness. This is true American womanhood, . . . not that of Washington Irving's day, when flimsy dresses were in style, which, like Mary Anderson's classic costumes, required to be dampened overnight to make them cling closely to the form. Paper-soled shoes were then in general favor, and those were the days of meager meals and of diseased and dyspeptic stomachs, hesitating hearts, pinched cheeks, and fragile limbs. Fashionable American womanhood of the past was a ghost.

"American womanhood of to-day is one of rosy cheeks, sparkling eyes, shoulders thrown back, firm and certain step. Notice how well nourished the cheeks are, how deep and true the inspirations, and how plump and well-rounded the arms, which taper down to the well-gloved hands. Is it not a glorious sight? There is no chance for paper-soled shoes here. Broad, substantially soled button boots cover the handsome, muscular feet, and in place of the tawdry costume whose likeness is preserved for us by dozens of old engravings, here we have a neat and well-made cloth suit, which fits the owner's form to perfection. Can any thing be more satisfactory to the eye than this picture of honest health, of alert though not perhaps of subtle intelligence and womanly beauty? There may be no suggestion of sentimentality here, nothing of what every-day novelists call poetry, and there is no romantic melancholy, but without any sacrifice of womanliness there is grace, and, above all, there are life and strength."

Fashion has committed many abominations in her day, and doubtless in the past deserved Dr. John Brown's wish that he could see her "dressed in her own crinoline, tight

shoes, a man's tall hat, and trailing petticoats, with her taper waist well nipped by a circlet of nails, points inmost, and with all the other small torments with which she makes us all fools, sent drummed, hissing, and blazing out the world;" but it should be remembered that never before in the knowledge of the writer have fashions been as a rule so sensible and conducive to health and comfort as at the present time. Even common sense shoes and the less objectionable forms of corsets may be found in the wardrobes of those who mold the fashions, which latterly do not arise solely from the caprices of queens and kings' mistresses, but from well-paid artists and thrifty manufacturers. When these shall learn to cater to the demands of health as well as to the eye the millennium for women is not far off. One of the most efficient workers to this end is a Mrs. Jenness Miller, of Washington, whose wit and beauty have succeeded in demonstrating that dress may be both healthful and beautiful at the same time. The great objection to the proposed Bloomer and Mary Walker dress reforms was that it left its adherent a hideous guy among women, and consequently all such advice was as useless as St. Anthony's preaching to the fishes. When, however, it can be proven that a woman can be both comfortable and fashionable at the same time, sooner or later comfort will win the day. This is exactly what Mrs. Miller is striving to do, arguing that fashionable follies and their resulting penalties have long enough been supreme. "No Greek ever dreamed of wearing sandals an inch narrower than her foot, and elevated on heels three inches high and located somewhere near the middle of the sole. Neither did she ever wear a sixteen-inch corset, or fasten an uncouth bundle of fantastic drapery to the small of her back with long skirts to trail in the mud. And if women again desire to be beautiful after the Grecian model they must abandon these abominations of fashion in the shape of long skirts with their endless complications of loops, puffs, and a weight that is death to health and happiness and to prolonged usefulness. Science objects to the practice of lacing, steeling and swad-

dling for the reason chiefly that it is inconvenient, ugly, and a burden of sorrow to the unborn world. Science also proposes dress without ligatures or bands, steels or whalebones —the essential thing being freedom from pressure, weight, and deformity. Science and sense abhor petticoats, corsets, and French heels."

Mrs. Miller therefore entirely discards corsets, petticoats, ligatures and bands, and clothes her body after this fashion: Innermost is a union garment of silk or wool for winter, fitting closely as a jersey. Over that is worn a muslin garment, also made to follow the form. Then leglets, or, in plain English, short trowsers, of material adopted to the season and made to reach just below the knee. Over this, without petticoats, hangs a dress made princess fashion, of any material preferred, but so cut as to place no weight upon the hips. Thus dressed a girl would be as untrammeled in her motions as a boy, and with as fair a chance for life, liberty, and the pursuit of happiness as Miss Alcott's "Rose in bloom."

Such girls and such doctors are few and far between, for the doctor is usually called in to repair damages after they have been inflicted, rather than to prevent them. The physician's best work is not to patch up dilapidated humanity, but to anticipate as far as possible such tinkering and repairing. The Chinese pay their physicians only so long as they keep their patients well, and while it might be impossible to successfully adopt their custom in this country, its principle is sound, and is the one on which a physician should be employed. According to Sir Henry Thompson, more than half of the sickness in the world is due to preventible causes which it would be far wiser to employ some one to anticipate rather than to cure their results. The best physician is not one with some 'pathy or proprietary salve, but the one who can best instruct his patients in regard to the care of their souls' houses, whose abuse inevitably brings penalties that are far more our own making than of divine interposition.

For instance, a principal in one of our larger young ladies' high-schools found himself greatly perplexed at finding his opening hour largely taken up in going from room to room and looking after pupils who had fainted or were otherwise indisposed. These attacks, at first so mysterious, were soon found to be due to over-fatigue, both social and mental, and a lack of a proper breakfast before school hours. No amount of prayer or physic cured such cases until more sleep, adequate food, and fresh air removed their cause; for fainting is not a direful disease, like the cholera, but is simply the blind protest of a brain not sufficiently supplied with the proper kind of blood. Since young ladies have given up living exclusively in-doors, fainting, says a recent society paper, has gone out of fashion; and it is a custom more honored in the breach than in the observance. The more so because usually exactly the wrong thing is done for one found fainting. The trouble is an insufficient supply of blood to the brain, due to a missed beat of the heart, either from feebleness or some mental impression—as bad news, the sight of fresh blood, or even a mouse; for there is no reasonable explanation of such antipathies. Boyle is said to have grown faint whenever he heard the splashing of water, Scaliger at the sight of water-cresses, and Erasmus notes the case of a clergyman who fainted whenever he heard a certain verse in Jeremiah read. But whatever the mental impression, its direct result and the one which causes the faintness is the failure of the heart to send sufficient blood to the brain; consequently the first thing to be done is to remedy this defect. Blood, like every other fluid, flows most easily down hill, and the common sense thing to be done is to lower the head of the one fainting below that of the body; so, when you find the world growing black before you, lay yourself out as flat as you can. Smelling salts, cold air, loosening the clothing and forty particular friends are all good enough in their place, except the last—who would do better to stand aside and let their friend have some fresh air; but the one great thing to be done is to put the head of a person in a

faint at least on a level with their heels. Fainting means that the supply of blood in the brain is insufficient, and of course the first thing to be done is to put the person in such a posture that blood will find its way most easily back. The thing usually done is to lift or set upright the victim, while the distracted friends crowd about and insist upon cutting off what little air would otherwise come to their aid. The recumbent position, a draft of fresh air, and a little water sprinkled in the face are usually all that is required in such cases, which are not at all alarming unless they occur in the course of protracted illness.

Under such circumstances repeated faintness is alarming, for it betokens failing ability of the heart longer to perform its duties. The wonder is that this does not oftener happen, for the heart is the hardest worked organ of the body; day and night, for our entire life-time, it pumps away seventy or more times a minute. To be sure it drives but six ounces of blood with each impulse, but as there are something over a hundred thousand of these impulses in the twenty-four hours it follows that the heart lifts over twenty tons of blood a day, and may perform this work for seventy years or more, without a rest of longer than a fraction of a minute at any one time. About one quarter of the time required for each beat of the heart is taken for rest; that is, for say each second its first half is occupied in making the sound *lup*, the next quarter second makes the sound *tup*, and then comes a quarter of a second rest, provided the heart beats but sixty times a minute. A longer rest on the part of the heart than a quarter of a second brings a feeling of faintness, and if the resting continues death ensues from heart failure, or syncope, as the doctors call it.

Solomon compares the heart to the wheel at the cistern, or the shadoof used in Eastern lands to lift the water from a spring to a reservoir. The comparison is good as relates to the method, but poor as regards the instrument, for the shadooff is an inefficient pump compared to the double handful of muscles which labor for us more incessantly than any

engine yet invented. Solomon's comparison is the more remarkable from the fact that in his day the circulation of the blood was not understood, although the pulsation of the arteries could not have escaped the attention of the ancient physicians. And yet it was not until the time of William Harvey (1619) that work done by the wheel at the cistern was understood. From the influence which the emotions have upon the circulation of the heart it was considered by the ancient Jews as the seat of the passions and the intellect, which were then supposed to be located in the breast and not in the brain. The error is not strange when we remember that excitement of any kind increases the heart's action. Even the difference between standing and sitting makes a variation in the heart's beat sufficient to be noted by many of the life insurance companies. Exercise of any kind quickens the heart's action, and hence benefits the whole body unless carried to excess. Boat-races, walking-matches, and foot-ball contests are dangerous when they call for violent work by the heart; so too does intense excitement of any kind, which leads eventually to enlargement of the heart and feeble action. A majority of professional athletes finally die either from this cause or consumption, strange as it may appear, although there is a good reason for the latter, as well as the hypertrophy of the heart so often found in such cases. Heart disease is frequently reported as the cause of sudden death, which is popularly believed often to take place without warning. Such is not the case. Heart disease rarely, if ever, causes death without premonition, and the majority of cases of unexpected death, supposed to be due to heart disease, are found to have other causes.

"A truer report would have a tendency to save many lives. It is through a report of 'disease of the heart' that many an opium-eater is let off into the grave, which covers at once his folly and his crime; the brandy drinker, too, quietly slides round the corner thus and is heard of no more; in short, this 'report' of 'disease of the heart' is the mantle of charity which the politic coroner and the

sympathetic physician throw around the graves of 'genteel people.'

"At a late scientific congress at Strasburg it was reported that of sixty-six persons who had suddenly died, an immediate and faithful post-mortem showed that only two of them had any heart affection whatever: one sudden death only in thirty-three from disease of the heart. Nine out of the sixty-six died of apoplexy—one out of every seven—while forty-six—more than two out of three—died of lung affections, half of them of 'congestion of the lungs,' that is, the lungs were so full of blood they could not work; there was not room for air enough to get in to support life."

Thus wrote Dr. W. W. Hall, some years ago, and increasing knowledge confirms his statement. It is furthermore proven that many cases of supposed heart disease are really those of chronic tobacco poisoning, and cease with the discontinuance of the weed. Tobacco's effects are chiefly expended upon the nervous system, which the poisonous alkaloid of tobacco (nicotine) affects. Tobacco has been dropped from medical use as too uncertain and dangerous a drug to be used with satisfaction, but half-grown lads persist in poisoning themselves with it until at last the body tolerates it and even demands its after-soothing effects. American hurry and worry doubtless have done much to beget the almost universal use of tobacco in this country, but, whatever the fancied need, tobacco cannot be used without paying the penalties. These are that it taints the breath, over-stimulates the kidneys, and saturates the skin with the characteristic odor of nicotine. It also disorders digestion, may produce cancer, and inevitably disorders sooner or later the heart's action. This is chiefly shown in rapid, irregular palpitations, short breath, languor, and, according to Franzel, sleeplessness. In one case in the writer's knowledge this sleeplessness bordered closely on delirium tremens, although the person did not use alcohol in any form. Such results are slow in appearing, the smoker often using tobacco for years without any supposed bad effects until going to consult his physician for sus-

pected heart trouble, without any idea that the use of tobacco has had any thing to do with the strange feelings and sudden pains about the heart ; he discovers their cause and he finds that the discontinuance of the use of tobacco brings relief from discomfort. And yet the habit is often so firmly implanted that the cessation of pain is usually the signal to begin anew the use of a drug that its user will freely admit he knows is injuring him. The fascination of tobacco, I presume, is never fully understood by one who has never been addicted to its use, but as strong men truly declare that a breath of tobacco smoke, after years of abstinence, has the power to force them to walk the floor all night in desperate conflict with their old enemy, it can scarcely be less irksome to be in bondage to tobacco than alcohol. Tobacco does not drive men to the gallows, or penitentiary, nor as a rule make moral wrecks of them, but it does put its devotee under a needless bondage, and whatever may be said in favor of its use by the overworked professional or laboring man, its effects upon growing youths are unequivocably bad. Decaisne found that in boys of fifteen it produced, almost without an exception, anæmia, palpitation of the heart, and an intermittent pulse, beside stunting the growth. In an English public school twenty-two of the thirty-eight juvenile smokers examined showed similar disturbance of digestion and circulation. So clearly has this been proven that in France the minister of public instruction, and certainly not from moral reasons, prohibits the use of tobacco in all the government schools, and the same is true, if the writer is correctly informed, in our naval training school at Annapolis, where tobacco is again on the prohibited list, after the experiment having been tried of allowing its free use. In short, science and experience unite in declaring, first, that the use of tobacco is not merely an expensive and undesirable habit for the young, but a positive injury, for no young man can ever reach his highest physical condition if he uses tobacco before reaching maturity (thirty-three years); and secondly, that cigarette-smoking is the most delete-

rious form in which tobacco is used. "A cigarette-smoking boy will not make a strong man. He will have impaired digestion, small and poor muscles, irritable temper, and a lack of capacity for sustained effort of any kind." (Bartholow.)

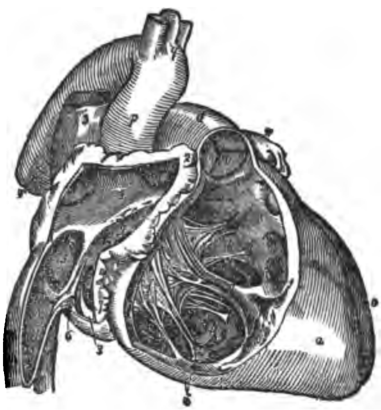
From a whiff of cigarette smoke to the size and shape of the heart requires one of Mark Twain's "natural and easy transitions;" but before leaving the subject of the heart it would be well to describe a little more fully its shape and location. The adult heart is a hollow, muscular organ about the size of a man's fist, of conical shape, located between the right and left lungs, its apex lying about an inch and a half from the surface of the body.

It is inclosed in a fibrous sac, called the pericardium, and lies obliquely in the chest, and so placed that a bullet penetrating the breast-bone on a level with the nipple, and striking the vertebræ at right angles with the axis of the body, would pass through three cavities of the heart; namely, both right and left ventricles and the left auricle.

The heart's base, or broad end, is directed upward and backward toward the right, and corresponds to the interval between the fifth and eighth dorsal vertebræ. Its apex, or conical end, is directed forward and to the left, lying in the interspace between the fifth and sixth ribs, an inch to the inner side of the nipple, where the heart's impulse can usually be distinctly seen on watching the bared breast. The lungs cover the greatest part of the heart, especially during inspiration, when the edges of the lungs nearly meet behind the breast-bone, behind the lower two thirds of which the heart mainly lies. A thin layer of lung tissue always covers the roots of the large vessels, but a large part of the heart's surface is exposed during expiration, when the edges of the lungs recede from each other. The anterior surface of the heart is rounded and directed upward and forward, and is composed mainly of the right ventricle. The posterior surface of the heart is slightly flattened, and rests upon the diaphragm; hence the

heart's distress when the diaphragm is pushed upward by gases within the stomach.

The heart in the adult measures five inches in length, three inches and a half in breadth in the broad part, and two inches and a half in thickness. The average weight in the male varies from ten to twelve ounces ; in the female from eight to ten ; its proportion to the entire weight of the body being as 1 to 169 in males ; 1 to 149 in females. The heart continues increasing in weight, and also in length, breadth, and thickness, up to an advanced period of life. This increase is more marked in men than in women.



Right Side of the Heart laid Open.

The heart is divided by a longitudinal, muscular septum, or division, into two lateral halves, which are known from their position as the right and left heart, and each of these is again subdivided by a transverse wall into two cavities, known as right and left auricles and ventricles, respectively ; the upper cavities on each side being called auricles, from their fancied resemblance in shape to an ear. The lower cavities are known as the right and left ventricles, according to their position. The right is the venous side of the heart, receiving into its auricle the dark or venous blood of the body through the venæ cavæ which empty into it. The course of the blood from this point is as follows: This venous blood passes downward through the tricuspid valve (*e*, *f*) from the right auricle into the right ventricle, whence it is propelled by the contraction of the heart into (*d*) the pulmonary artery, its return into the auricle being prevented by means of the tricuspid valve just mentioned ; and its regurgitation from the pulmonary

artery back into the ventricle is similarly prevented by semi-lunar valves (*m*) placed at the cardiac orifice of the artery. By the pulmonary artery the blood, still blue and venous, reaches the lungs, where it loses its dark color by the processes to be described, and now becomes bright red. Having been thus purified, it returns to the heart from the lungs through the pulmonary veins, which, however, convey arterial blood, and empties into the left auricle, well shown in Plate II.

These veins, unlike the majority of the vessels which empty into the heart, have no valves at their openings into the left auricle, so that there is a slight reflux of blood toward the lungs, but the greater part of the blood which passes into the left auricle is forced by the contraction of the heart through the mitral valve (*m. v.* Plate II), which separates the left auricle from the left ventricle. From thence it passes through the semi-lunar valves, which are designed to prevent the regurgitation of blood back into the heart, into the aorta, and carried the round of the circulation, until the blood reaches the capillaries, hereafter to be described, from which it at last reaches the veins, and ultimately the venæ cavæ, or great veins which empty into the right side of the heart. The course of the blood through the heart has already been described, and if the round of the circulation seems somewhat intricate, by reference to Plate II the matter may be greatly simplified and fixed permanently in the mind of the reader, as the arrows given in the plate indicate the direction of the blood currents, and their color shows whether they are those of arterial or venous blood.

The heart sounds already alluded to, which can readily be heard by applying the ear to the bared chest, just above the location of the apex beat, are due to the rhythmic contractions of the heart forcing the blood through its partitions and out into the general circulation. If you listen attentively you may be able to distinguish, first, a longish, dull sound which has been likened to lup, then a shorter—about one half the duration of the first—sound, called tup, and then a

pause for the same length of time as the second sound; then comes the first sound again, and so on, the first sound occupying one half the time of a heart-beat, and the second and the pause the other two quarters. The first, or lup, sound is probably produced by several causes, the second is due to the flapping back of the semi-lunar valves (*l. v.*) at the aortic opening (see Plate II). Sometimes these and the other valves in the heart become diseased, especially after or during rheumatism, and their owner ever after suffers from a leaky blood-pump, which will not allow him to run or take violent exercise for the remainder of his life. And yet, with care, many of these leaky hearts perform their duty for a surprisingly long time, and, contrary to general belief, rarely sentence their owners to sudden death. In fact, with any thing like reasonable care the heart is more tolerant of protracted work than any other organ of the body, and so long as a regular full pulse can be felt at the wrist the less thought given the heart the better.

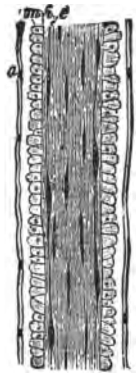
The pulse, or impulse given to the fingers laid over an artery, is due to dilatation of its elastic walls each time a fresh quantity of blood is forced into it. Hence it closely follows each contraction of the left ventricle, and counting the pulse gives us the number of these contractions during the minute. The jets of blood from a freshly cut artery give us the same information; but such knowledge is dearly purchased, for if long persisted in it brings death from loss of blood. As long as the blood flowing from a wound is dark-colored, even though it comes freely, it need cause no particular alarm, for pressure over the wound will usually stanch the flow; but crimson spurting blood must be stopped at once by the surgeon, and until he comes a bandage should be placed around the limb between it and the heart, and twisted as tightly as possible by thrusting a stout fork or strong stick beneath the bandage, and thus twisting the bandage until sufficient pressure is obtained to check the flow of blood. Pressure is the only thing that can be relied upon to check arterial hemorrhage, but, intelligently used, it

will and has saved many a life until professional aid could be obtained.

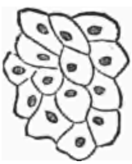
Having now considered the blood and the heart, there remains but little in the way of description of the blood-vessels to complete the mechanism of the circulation. These blood-vessels are of two varieties; namely, arteries and veins. The former were originally called arteries, from the idea entertained by the ancients that these vessels contained only air, which mistake arose from the fact that the arteries are usually found empty after death. Galen was the first to refute this opinion, for he was able to prove that the arteries contain blood in the living body. Except in the case of the pulmonary artery, they contain bright red, or well aerated blood. The pulmonary artery, as may be remembered, although it is called an artery, conveys venous blood from the heart to the lungs, whence it is returned by the pulmonary veins to the other side of the heart, constituting what is sometimes known as the lesser or pulmonary circulation, whose arteries and veins contain exactly the reverse of the blood found elsewhere in the body; that is, the pulmonary veins contain arterial blood, and the pulmonary artery venous blood.

The arteries are round, fibrous tubes, dense in structure, quite strong, and elastic enough when cut to preserve their cylindrical form. The arteries have three coats or layers, and are also included in a sheath, which holds in addition generally a vein and nerve. Arteries give off branches which freely communicate one with another by means of larger and smaller branches. These anastomoses, as they are called, are found wherever great freedom in the circulation is required, as at the base of the brain and about the joints. The arteries and their branches divide and subdivide, until in its general contour the arterial circulation resembles an inverted tree whose common trunk would be represented by the aorta and its twigs by the capillaries, which are found in nearly every part of the body except in the nails, hairs, cartilages, and cornea. The capillary blood-vessels are so named because

in size they are about that of a hair or less (one fifteen-hundredth to one two-thousandth of an inch), sometimes disposed in loops, sometimes in meshes, in which the blood almost imperceptibly passes from the arterial to the venous side of the circulation. Just how this change is made is somewhat in dispute, but the following facts seem well attested. The larger arteries, as has already been said, possess three coats, and, as the arteries grow smaller, these coats imperceptibly disappear, until the capillaries have only the inner (endothelium) left, which, as may be seen from the cut, is made up of endothelial plates, or germinal matter set like tiles in a cement substance. These arterial twigs communicate with the venous capillaries either directly or by means of intervascular spaces, into which the corpuscles pass by means of the minute openings between the endothelial plates. This always takes place in inflammation, when these capillaries become abnormally distended, and the openings between the plates so much enlarged that the white corpuscles (pus) readily pass through them. The veins are formed by the union of the venous capillaries, which are found in nearly every tissue of the body. These venous twigs unite to form venous trunks, which increase in size as they pass toward the heart by union with other veins on the way. In general, the veins are larger and more numerous than the arteries, so that the entire capacity of the venous system is much greater than that of the arterial. From the combined capacity of the smaller venous branches being greater than the main trunks, it results that the venous system represents a cone, the summit of which corresponds to the heart, its base to the circumference of the body. In form the veins are not perfectly cylin-



MINUTE MICROSCOPIC ARTERY. *e*, Endothelium; *i*, intima; *m*, muscular media, composed of a single layer of circularly-arranged non-striped muscular cells, *a*, adventitia.—*Klein.*



Endothelial plates.

drical like the arteries, their walls being collapsed when empty, and the uniformity of their surface being interrupted at intervals by slight contractions, which indicate the position of the valves placed within them to prevent the backward flow of the blood. These valves are formed by a reduplication of the inner and a part of the middle coat of the vein, and consist, therefore, of connective tissue and elastic fibers, covered on both surfaces by endothelium. Their form is semilunar. They are attached by their convex edge to the walls of the vein; their concave margin is free, directly in the course of the venous current, and lies in close apposition with the wall of the vein so long as the current of blood takes its natural course; if, however, any regurgitation takes place, the valves become distended, their opposed edges are brought into contact, and the current of blood is intercepted. Most commonly two such valves are found placed opposite one another, especially in the smaller veins, and in the larger venous trunks at the point where they are joined by small branches.

Just above the valve the wall of the vein expands into a pouch, which gives a vein its knotted appearance when distended with blood. These pouches are especially numerous in the veins of the legs, which are thus provided to assist the blood current, against gravity, toward the heart, where all the veins at last empty. Increasing age is apt to produce enlargement of these pouches (varicose veins), which become a serious impediment to walking, but which may be relieved by snug bandaging. A more serious accident is the formation of a fibrinous clot in a blood-vesssel or the fatty degeneration of their walls. Alcohol is a frequent cause of this, and such vessels are prone to rupture. This accident in the brain is apoplexy.

There are two hundred and seventy arteries, and as many or more veins, all of which are of interest to the anatomist and surgeon; but instead of attempting a description of the more important of these, we give a cut illustrating the relation of the aorta, or great artery of the body, to the other

large vessels of the trunk of the body, which for further comparison should be studied in connection with Plate II.

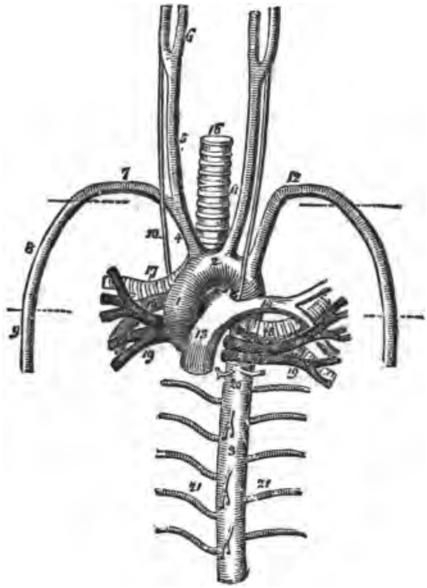


DIAGRAM OF THE LARGE VESSELS OF THE HEART AND LUNGS (FROM WILSON).

1. Ascending aorta.
2. Transverse portion of the arch.
3. Thoracic or descending aorta.
4. Arteria innominata.
5. Right common carotid.
6. External and internal carotids.
7. Right subclavian artery.
8. Axillary artery.
9. Brachial artery.
10. Right pneumogastric nerve.
11. Left common carotid.
12. Left subclavian artery.
13. Pulmonary artery.
14. Left pulmonary artery.
15. Right pulmonary artery.
16. Trachea.
17. Right bronchus.
18. Left bronchus.
19, 19. Pulmonary veins.
20. Bronchial arteries.
21, 21. Intercostal arteries; the branches from the front of the aorta above and below the number 3 are pericardiac and esophageal.

CHAPTER V.

SEWERAGE AND VENTILATION.

IN the preceding chapter we have briefly considered the composition of the blood and the mechanism of its circulation. This naturally brings us to the question, Why is the blood thus carried its ceaseless round? Because if delayed at any one point the blood there stagnates, grows blue, distends the tissues, and finally, by an escape of its corpuscles, produces death of the part. Such an accident is called in its earlier stages congestion, later it is known as mortification. Congestion happens whenever the nerves which preside over the circulation of any organ fail to do their duty; for each tiny arterial twig has its own nerve connections which regulate the quantity of blood contained by contracting or dilating the vessel as required. The pallor of fainting means that there has been a sudden contraction of the little vessels upon the surface of the body, driving the blood to the internal organs. Blushing denotes exactly the contrary, or that the vessels are widely dilated, from shame or other causes, and no longer able to contract. Congestion is a protracted blushing, that is, a continued dilation of the capillary blood-vessels from any cause, and serious in proportion to its persistence. Congestion of the lungs is a more frequent cause of death than heart disease, while transient congestion is a matter of every-day occurrence and of little importance, provided the equilibrium of circulation is soon restored. A hot fire, a cold walk, wet feet, all produce localized congestion, but of a kind that is quickly relieved if one is in health; but if, as the doctors say, the system fails to react, a pair of thin shoes or a cold walk may prove the cause of untimely death. The late Dr. Durbin's rule of never allowing himself to become chilly is

an excellent one, for one can never be sure that he is in condition to react after even a slight chilliness. Thin slippers may look very beautiful upon the tiny feet which peep in and out like mice beneath the petticoat, or the excursion with bare feet from the warm bed to the cold floor may be of but a moment's duration; but that moment may suffice to drive the blood from the surface of the body to your lasting injury. Chilliness is always a sign that something is going wrong within the house in which we live; for a chill is nature's automatic alarm, by which the sympathetic nervous system gives warning that the tiny blood-vessels over which they watch are being imposed upon. If you are wise you heed the warning, and at almost any personal inconvenience by means of hot drinks and baths bring about a reaction. If this is done promptly, no harm results; but if the blood-vessels have been too long contracted, instead of returning to their former condition they expand to an undue amount and now contain twice as much blood as they ought. In other words, you find your nose is all stopped up after catching cold, because its blood-vessels have crowded into them twice or thrice as much blood as they can conveniently hold; for one of the spots most liable to become chilled is the sensitive membrane lining the nose. The swelling renders it almost impossible to breathe through the nostrils, and if the congestion passes downward there is hoarseness as well. If, on the other hand, the cold is confined to the head, the swelling passes up into the bone cavities communicating with the nose and lined with the same mucous membrane, and there is headache, and we feel generally too mean to live, until here, as elsewhere, nature does the best thing that she can under the circumstances. And what is that? Why, relieve the swollen blood-vessels as promptly as possible by allowing the excess of fluid to transude through their walls.

Hence we often find the sneezing and irritation in the nose, of the first few hours of a hard cold, disappear as soon as there is an active demand for handkerchiefs. Now if we have

sense enough to give nature sufficient time to thoroughly repair the errors we have committed, we are none the worse for the experience, which otherwise might have been pneumonia or something more serious, but in this country we are generally too much in a hurry to get thoroughly well. Some very important sewing society engagement, or call to save the country from impending danger by the aid of our invaluable advice, tempts us out, and we repeat the congestion before it is thoroughly well. The natural result is that we find ourselves at last afflicted with catarrh, or a chronic discharge from some one of the air passages—for nature after a while gets tired of her repeated efforts at repair, and at last abandons us to our own devices and those of the physicians. These at best are a poor substitute for nature's original methods, as we find at last, to our regret, when a cold is no longer a trivial matter. Curiously enough, cold has, ordinarily, very little, if any thing, to do with catching cold. Indeed, some think that the very best way to cure a cold is to breathe as much cold air as possible, and the colder the better; but there are colds and colds, and while some are, beyond dispute, contracted by sitting in a cold draft, there are other colds, and these are the more frequent ones, which are due to impure air and a generally clogged up system. The bad air produced by the modern hot-air furnace is a prolific source of winter colds, as are also poorly ventilated churches, theaters, and other places of public resort, especially if to the bad air be added improper diet. Any kind of food, of which more is taken than can be easily disposed of in the body, begets a susceptibility to colds which needs only some slight cause to fan it into an active congestion. So true is this that if you find an overfed child and house him in furnace-heated apartments all winter, no amount of care will prevent his having frequent colds, whereas if the same child be properly bathed, housed, and fed he will in the great majority of cases escape this affliction. At all events, whatever may be the rationale of a cold, the fact remains that the very best treatment yet devised for an incipient cold is star-

vation. "Feed a cold and starve a fever" has made lots of mischief, for whatever may be said of the treatment proposed for fever it certainly is most excellent for colds. The trouble is to induce one's friends, or even one's self, to carry out the prescription. You are a little feverish, achy, with a bad taste in your mouth, and generally feeling worse than an organ-grinder's monkey, when a meal is announced, and from force of habit, or want of something better to do, you sit down and force yourself to eat, although you know you do not need it. For a while, eating distracts your attention and calls it away from yourself, but shortly after the meal the cold grows worse than ever. In other words, the body while suffering from a cold very imperfectly attends to digestion and elimination, and any thing that increases its work in that direction increases our discomfort. The sensible thing to do when a cold is coming on is to stop eating entirely, and for a day or two to live on hot beef-tea and other liquids. Many a cold treated in this way yields most gratifyingly in a few hours. Indeed, if the dear people would but learn to keep their feet dry, their heads cool, and their bodies properly protected, a large share of the doctor's work would be sadly cut into. But the majority will not. It is too much trouble; it takes too much time to put on wraps. We are too indolent to carry an overcoat for emergencies. We are loth to deny ourselves the pleasure of eating, so we drag out a week of wretchedness, which might be cut short by a day or two of abstinence, or just as long as feverishness persists ; for a cold is always attended with fever. There may be a feeling of chilliness, but a thermometer placed in the mouth will register one or two degrees higher than in health. This fever is due to the disturbance of the capillary circulation already described, associated with inflammatory changes in the germinal matter of the skin and mucous membrane, which is only a turning of the skin inward to line the cavities of the body, for mucous membrane is the same three-ply tapestry found on the surface of the body.

The lower layer of mucous membrane is the same corium

that has already been described in speaking of the skin. It has similar fibrous tissue, vessels, and nerves, over which lies a thin transparent basement membrane, and on top of this lie epithelial scales or cells. Epithelium and endothelium are the poorly selected Greek names given to these wondrous bits of germinal matter with which the body is lined inside and out. The scales of the mouth are well named, for a scraping with a penknife from the inside of the lips shows beneath the microscope a multitude of flat scales not unlike those that may be found upon a fish. But this is not their only form, for elsewhere in the body they have the shape of columns, waving tufts, tiny spindles, goblets, chalices, and polygonal plates, each one placed where it can best perform its special work.

The essential difference between the epithelium on the surface of the body and that within its cavities is that the former is protected by a layer of dried scales, and the latter is without these, being bathed constantly instead with a bland fluid. The rosy, glistening mucous membrane of the lips is exactly the same as the skin minus nature's coat of whitewash, for a blister that has just been drawn has about the same appearance as the lips. If, then, mucous membrane is so nearly like blistered skin, why don't we feel all raw inside? We should if it were not for a beneficent arrangement by which this membrane is kept constantly bathed in a bland fluid (mucus). Holding a blistered finger in milk will take away the smarting quicker than almost any thing else; so there are myriads of little sacs or mucous glands scattered all over the mucous membrane whose duty it is to keep it moistened with a thin, watery fluid, and at the same time wash it clean from refuse; for it must be remembered that mucous membrane is as constantly growing as the skin, and needs to be kept clean as well. Do you remember those days of protracted fever when your mouth was as dry as a chip and tasted like old leather and copperas? That simply meant that the mucus was not sufficient to wash away the growing epithelial scales, which were left to dry and rot

there; and no wonder your mouth tasted badly. But that is not all; there is another set of glands pouring fluid into the mouth, and at such a time these are tainted as well. These are the salivary glands, already spoken of under Digestion. Their deficient and tainted secretion makes the mouth dry, and awakens a desire for lemonade or other acid. Refraining from fluid may help to cut short the inflammatory trouble, but it is done at a cost of personal inconvenience few feel willing to submit to. Moreover, as recovery in these cases results from the removal, from the blood and fluids of the body, of the poisonous substances whose accumulation there produces the fever and discomfort, this process is assisted by the free use of fluids. These stimulate the kidneys, skin, and mucous glands to increased action, and, as we have all learned, when the latter begin to act freely the fever of a cold disappears. The bad taste in the mouth may linger for a few days, with loss of appetite —which means clearly that it is better to refrain from eating until the appetite returns and the tongue cleans. Starvation usually brings both promptly to time, though in the case of the tongue the process may be hastened by cleaning off its refuse with the edge of a silver fruit-knife and scrubbing up after with a little saleratus water. There is no better reason for leaving a dirty tongue in one's mouth than for neglecting to clean the teeth. It was once the fashion for every lady to keep on her table a tiny silver hoe with which to clean her tongue after dining, not wisely but too well, the previous evening. It was not an irrational practice, in fact vastly wiser than the modern plan of taking stomach or liver bitters when, according to the advertising almanac, you answer in the affirmative its staple questions of, "Are you dull and heavy in the morning? Have you a bad taste in the mouth? Is your appetite poor?"

These symptoms need attention; they mean that your body is growing dirty, and possibly needs a spring house-cleaning, but that is a very different thing from putting its servants to sleep with alcohol, so that they will not know

whether the house is dirty or not. Taking stomach or spring bitters means exactly this. As I write there lies before me the official analysis by the State chemist of Rhode Island of all such bitters on sale in that State, and there is not one which does not contain alcohol, the most popular (Hostetter's and Drake's) being stronger than brandy. A wine-glass of brandy twice or three times a day makes the drinker feel comfortable while its effect lasts, but that gone there is need of another; and such is exactly the effect of these much-advertised bitters, which are all the more dangerous because they are taken by many who would utterly refuse to take liquor, and yet ignorantly take daily poor whisky enough to keep them just within its influence. The effect of alcohol upon germinal matter has already been noted in Chapter I. It is not necessary here to further discuss the subject, except to say that after liquors have done their work within the body their alcohol is excreted through the lungs and kidneys. In both of these places alcohol works mischief. Its passage through the delicate tubes of the kidneys, hereafter to be described, damages their epithelium often irreparably, and the alcohol escaping through the lungs does no less harm, for, aside from the foul odor it gives to the breath, it so irritates the air passages that "whisky drinker's bronchitis" is a well recognized form of disease.

Of minor evils a bad breath is one of the most annoying of troubles. Aside from that due to whisky, onions, and tobacco, it betokens *dirt* somewhere. Dirt was happily defined by Palmerston as "matter in the wrong place," and there is no instance of worse misplaced matter than putrefying material coming out between rosy lips. A bad breath is thus produced, though it is often quite difficult to find out exactly where the decay is taking place. Sometimes the trouble is with the food in the stomach; sometimes it arises from decaying epithelium on the tongue, and again it comes from the perverted secretions of the tonsils or the nostrils. Whatever the source, such odors, as in all dirty houses, call for

increased cleanliness. Cleanliness in the body means that all refuse must be either swept out or burned up, for if any residue of unused food escapes these processes, like all other organic matter it begins to ferment and becomes a nuisance. Strict search should be made for the corner in which such bodily nuisances originate, and these thoroughly deodorized, and all pains taken to prevent their recurrence; for latterly we are coming to believe that much of our disease comes from bodily filth and its results. A wonderful change has come in public opinion since the time of the Middle Ages in regard to the matter of dirt.

The early Church so far forgot Moses's teachings on this subject that filth and sanctity were supposed to be necessarily associated. Like the East Indian fakirs of to-day, the greater their personal uncleanliness the greater the odor of sanctity, and other odors, doubtless, as well. There is, for instance, a Church tradition, and a most improbable one too, that St. James never took a bath, and a much better authenticated one concerning St. Anthony, whose biographer declares that "up to extreme age he never even washed his feet, and yet was healthier than those who bathe and often change their clothes." (No wonder he is the patron saint of erysipelas.) Saint Hilarion must have been a kindred spirit, for history relates that he never washed the sackcloth which he wore until it rotted off, like the rags of an Egyptian hermit spoken of in highest praise by St. Jerome. The last named saint only combed his hair on Easter Sunday, and, like St. Abraham of Edessa, never was known to wash his face. "The fourth century," says a recent writer on this subject, "was the religious apotheosis of dirt, not because the hermits and Church had any quarrel with clean skins, but because of the sensuous delight and comfort of bathing in hot climates. Bathing was one of the luxuries renounced at baptism, and fulminated against by various bishops and councils as late as the fifteenth century."

"Like priest, like people," brought its inevitable results in the way of plague, black death, and the other awful epidemics

of the Middle Ages. With our modern resources of quarantine and cleanliness, we can have no just idea of the terror and fearful mortality produced by these filth diseases. Black death, for instance, between the years 1333–1348, is believed to have killed upward of 45,000,000 persons. The very means devised by the Church to stay their progress—namely, masses, processions, and flagellations—were exactly those which assisted the spread of contagious diseases, for such they were. The general dispersion of the people from their filthy abodes at last brought these diseases to a close, not because, as was then believed, the wrath of an angry God was calmed, but because his creatures had ceased violating the unchangeable laws of health.

Medicine is often reproached with its slow advance compared with other sciences, but it should be always remembered that medicine has made such epidemics impossible again. A better knowledge of the spread of contagious diseases, of the value of quarantine and the danger of filth has brought this to pass. According to Erasmus, the filth of the English home, in his times, must have been almost past endurance; for not only the hovels of the poor but the homes of the well-to-do had their floors of clay covered with rushes, instead of carpets, under which lay an unmolested accumulation of half-picked bones, decaying grease, stale beer, and other unmentionable things which need not be described with the particularity of Erasmus. The table manners of those days (1457–1536) were equally startling, if we may judge from some of the don'ts of the books of the etiquette of that time. For instance, we find that it was considered "uncomely to spit on the table," and "improper, after rinsing the mouth, to reject the water into the basin again," as others would wash their mouths from the same vessel. Handkerchiefs and forks were entirely unknown to Englishmen, when it was good form to hold the "joint in the left hand and carve with the other; after which the fingers should be wiped on the shirt, and not on the table-cloth." Small wonder that with such habits there came dreadful

diseases like the sweating sickness, the black death, and the plague. The proper care of the body and our homes has abolished, forever, as it seems, these dread pests. Our modern epidemics are insignificant as compared with those of the Middle Ages, and the most dreaded of these—cholera—could probably be practically annihilated by proper sanitary regulation of the pilgrim gatherings at Mecca and on the Ganges. (See page 68.) Public health can only be obtained by individual cleanliness, and this implies that our bodies, like our houses, shall be well-ventilated and clean outside as well as in. To be happy and well requires that we shall be clean, within and without.

I. The skin must be able to perform its duties properly. The structure of the skin has already been described (page 14), and does not need repetition here further than to call attention to the fact that it is more than an elastic bag, in which are held the muscles and bones. The skin is both a secreting and excreting organ as well. The distinction between a secretion and excretion is this: A secretion is a substance formed for further use by the body, while an excretion is a substance that is taken away, because useless or dangerous to the body. The tears, for instance, are secretions, for the reason that they are needed to wash away irritating substances from the eyes, while urea is an excretion whose continuance in the body produces convulsions and death. Secretion and excretion are performed mainly by bodies known as glands, located in various parts of the body, and modified in shape in accordance with the work they are expected to perform. We find two varieties of glands in the skin by which it carries off about one fourth of the liquid sewerage of the body. The sebaceous glands have already been described, and the other and more important of the glands of the skin are the sudoriferous glands, so named from the Latin word for perspiration. These sweat glands, already figured on page 14, number over two million, and consist of spiral tubes, each about one fourth of an inch long, but so numerous that they aggregate in length about two and

a half miles. They are not uniformly distributed over the body, being less in number on the back and neck (four hundred to the square inch) and most frequent on the face, palms of the hands, and soles of the feet. In a bright light on a warm day the moisture can be seen to ooze from the open ends of these sweat-glands in minute drops; hence the disagreeable moisture of the hands in bashful persons, for the quantity of perspiration is regulated by the amount of blood in the capillaries, and this, as we have seen, is under the control of the nervous system (see Chapter VII.).

A limited amount of perspiration always takes place even in the coldest weather, as may be proven by wrapping a limb for some time in an impermeable substance, as a piece of India rubber, and examining it after a few hours. Although the rest of the body appears perfectly dry, that beneath the rubber will be found moist, and if the wrapper has been kept long enough in place it will have a decidedly unpleasant odor from the retained excretions; or, in other words, invisible perspiration is constantly taking place, but is unnoticed unless its evaporation is prevented. Clothing in a measure does this, and hence is wisely laid off at night to allow this insensible perspiration to escape, and even then at length clothing acquires a goat-like odor, due to the volatile fatty acids which escape with the perspiration. This can be in a measure removed by baking the offensive clothing when it cannot be washed, but the appearance of such odor is either proof of the need of more frequent bathing, or that the clothing has been worn for too long a time and ought to be destroyed, and fresh underwear and bathing employed.

Much that goes under the name of a bath as little resembles it as the historic one prescribed for the Duke of Gloucester, which was thus prepared: "Five or six large sponges were first placed upon the floor for the duke to sit or lie upon, and a larger sponge was then placed in the middle of the room with a sheet spread over it, after which the duke, having been stripped, was made to sit upon the largest sponge, while another dipped in a hot decoction of herbs was to be lightly passed

over the body; after which rose-water was splashed over him, as a rinsing. The duke was then dried by being wrapped in a sheet and marched off to bed to cure his troubles." This was the ideal bath in the times of Shakespeare, for it was for one of his characters that this particular bath was ordered and administered, to what advantage we may readily guess. A bath to be efficient for cleansing thoroughly the skin ought to be warm, and large enough in quantity to cover the whole body, and long enough continued to wash free the dried epidermis and sebaceous matter which clog the openings of the glands.

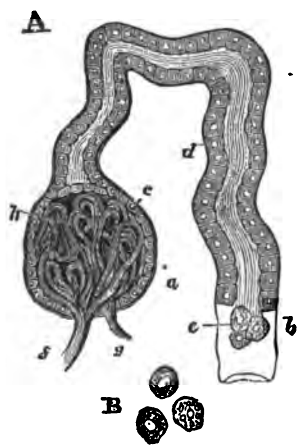
Perfect health requires, for two reasons, that the glands of the skins should act efficiently: 1. The sweat-glands thus promptly relieve the blood of any excess of liquids. How quickly this is done may be tested by drinking in succession two or three glasses of cold water on a warm day. Hardly is the last one swallowed before the whole surface of the body is covered with moisture. To produce this the absorbents of the stomach must have taken up the water and, *via* the lymphatics, carried it into the current of the circulation. The slight excess of fluid was sufficient to distend the capillaries of the skin. This distension and thinness of the blood caused its watery portion to transude through the frail walls of the capillary and into the cavity of the sudoriferous tubes, from whose open ends it exudes upon the surface of the body in less time than it has taken to tell of it. Perspiration thus relieves the tension of the blood-vessels, and carries off dangerous substances from the body. So important is this function that to coat the body with varnish or with gold leaf, as once did one of the popes with a slave in a triumphal procession, inevitably produces death, from the inability of the kidneys to carry off effete material: 2. But perspiration does more than this. Its further duty is to regulate the external heat of the body. Evaporation of any kind requires heat to be abstracted from some neighboring body. The evaporation from the surface of the body is carried on under the same laws as elsewhere, but within our own bodies we find this beautiful provision in

regard to heat; namely, that the warmer we become the more we perspire, the more we perspire the greater the evaporation of this perspiration, and hence the more rapid the cooling of the body. The sudoriferous glands, then, are a sort of heat regulator for the body, and so well do they perform their work that we have little fear of sunstroke so long as one perspires freely; but when perspiration does not appear on a sultry day, sunstroke, or heat apoplexy, is not far off. (Sunstroke, until the doctor comes, can be best treated with ice or cold applications to the head, and plenty of cool water poured over the overheated body.) A dry, branny skin is always to be looked upon with suspicion, for unless it can be made to properly perform its work it is very apt to sooner or later result in some obstinate skin disease or kidney trouble. The amount of water that may pass through the skin without injury is remarkable, as for instance at the Swansea copper furnaces, where the thermometer at the chest of the stoker marks 120 degrees and that at his back but 50 degrees. To meet this intolerable heat he drinks freely, at least two or three gallons daily, and perspires accordingly—500 to 600 gallons a year—and yet is none the worse for it, but lives to a hearty old age. Sweating is often disagreeable, to put it mildly, but it is so valuable a discomfort that it is far better to perspire than carry about with us the pound and a half of dangerous material that it is designed to relieve us of daily. The only precautions to be observed in the matter are that we must not allow this effete material to gather in our clothes, nor ourselves to become chilled when moist with perspiration. The amount of perspiration determines the frequency of bathing required, but the minimum should be a weekly bath, apropos of which Dr. Hunt very candidly remarks, "We have never known a person by nature so cleanly as not to be benefited by at least a weekly bath." His further suggestion that the best time for taking a bath is at night is worth remembering. A sponging of the neck, head, and chest on rising is also an excellent tonic, and as preventive of sore throat and colds is not sufficiently appreciated.

A climate so changeable as ours requires woolen underwear, of varying weight for different seasons of the year, as the only safeguard against chilling of the surface of the body. There is a great difference in the susceptibility of the skin in persons, but even the most sensitive one will tolerate the long-fibered woolen garment, and where this cannot be afforded, the lighter grades of flannels can be used with a muslin garment beneath. The value of such protection of the body can hardly be overestimated, for it keeps the skin gently stimulated to action and prevents the congestion of internal organs, which happens whenever the blood is driven from the surface of the body. Flannel well deserves a high place in the doctor's regard, for the physician who attempts to cure rheumatism, bowel, or kidney troubles without its aid has thrown away his best medicine.

In these latter days kidney diseases have become the bugbear of all intelligent readers. There is hardly a board fence or a religious paper that does not serve to advertise some one's sure cure for Bright's disease, until one is sorely tempted to wish that Dr. Bright had kept his discoveries secret. Quack almanacs and Safe Cures have gathered so rich a harvest that it would almost be better for the world at large if they could believe with the ancient Jews that the kidneys were the home of the affections. The kidneys, or reins, as they were formerly called, are simple sacs in the lowest animals, but as the animal rises in the scale of organization the kidneys become more intricate, until in man they are so complex that it is hardly possible to describe them properly without further illustrations than can be here used. Essentially, however, the kidneys are clusters of sudoriferous glands which do their sweating inside of the body, and whose tubes bear the name of uriniferous tubules instead of sweat-glands. Through these tubes the watery portion of the blood filters through the kidneys, very like the perspiration on the surface of the body; and in fact in the older works on physiology the kidneys and skin are spoken of as the common emunctories (filters) of the body. The work of the one can in a measure

be done by the other, as is seen in summer, when the secretion from the kidneys is small and that from the skin profuse, while in winter exactly the contrary is found. A cross-section of a human kidney shows that it is made up of two parts, a cortical, or outer, and an inner, or medulla, composed of eight to twenty cones, the so-called pyramids, whose apexes point toward a central cavity, from which a tube about the size of a goose-quill runs to the bladder. On the apexes of the cones are found a multitude of minute openings which correspond to the opening of the sweat-glands upon the surface of the body, and through which fluid is likewise continually passing, by filtration from the blood. The tubes on the skin are called sudoriferous tubes, in the kidney they are known as the uriniferous tubules, and if we follow up one of these tubules from the kidney, from its opening on the surface of a pyramid, we shall find that it terminates in a dilatation not unlike those found in the sweat-glands. The dilatation in the urinary tubule is known as the Malpighian (from its discoverer, Malpighi) capsule (see figure *b*), which incloses within it a network of capillaries (glomerulus) given off from the branches of the renal artery. Through this tuft of capillaries the liquid refuse of the blood exudes and passes into the tubule, making its way down this until it at last reaches the bladder. The Malpighian capsule, then, is a funnel, and the glomerulus a network of delicate filters to extract from the renal blood what should be carried away from the body as liquid sewerage. The quantity of this varies considerably with the season of the year and the amount of liquid taken, but the total urine should be slightly above the amount of water taken during



Urinary tubule. (Huxley.)

the twenty-four hours. A persistent variation from this indicates something wrong in our plumbing department. The most frequent error arises from too sparing a use of water to avoid annoyance. Professor Vaughan says very plainly on this subject: "The merchant goes behind his counter, and to avoid frequent visits to the water-closet drinks but little water. The same mistake is made by ladies who are out in society much, and by the student who does not wish to be interrupted in his studies by the calls of nature; but the result is that the urine becomes small in amount, strongly acid, of high specific gravity, and deposits urates, uric acid, or oxalate of lime which produce irritation of the bladder, or even gravel."

A false squeamishness in these matters often inflicts permanent injury, for the urinary apparatus is a delicate bit of machinery, lined with epithelium as sensitive as that on the lips, and so located that when once diseased it inflicts serious injury upon the kidney. By reference to the cut on page 142, it will be seen that the entire length of the urinary tubule is lined with epithelium. This when diseased or removed by sickness allows the fibrinous part of the blood to escape into the tube and there solidify and form a "cast," or it may escape so rapidly that the person dies of exhaustion. Such injury to the tubules constitutes Bright's disease, apparently upon the increase in America, from a variety of causes, chief among which may be noticed mental strain and a too largely meat diet and exposure to cold and wet, etc. The nervous theory of kidney disease may not be generally accepted, but it is well known that the nervous system has a marked influence in the matter. Fright or hysteria may largely increase the urine, and, *per contra*, irritation of the nerves which supply the vessels of the kidney has, according to Huxley, the immediate effect of stopping the excretion of urine. And, lastly, any physician who has carefully watched the progress of a chronic case of kidney trouble will tell you that business anxieties and responsibilities invariably aggravate such cases, whose only chance for permanent recovery is to escape from all kind of anxiety, dress warmly, and avoid a

too largely animal diet. The latter is strongly insisted upon by Fothergill, and with a good show of reason, for those nations that are most largely meat-eaters are those most afflicted with kidney troubles. The reason given for this is as follows: Nitrogenous foods are exuded from the body as urea. Meat is our most largely nitrogenous food. Excess of urea stimulates the kidneys to overaction. The more meat, the more urea, the greater the stimulation of the kidney to its own hurt. Next to Australia, we are the greatest meat-eaters on the face of the earth, and consequently, says Fothergill, grievously afflicted with kidney affections. The red or white sediment often found in the urine is often a cause of anxiety, but it has no causal relation to kidney disease, and usually indicates, as has already been said, that sufficient water is not being taken to keep the drainage pipes well flushed out. More water generally will cure the majority of these cases, except where a cayenne pepper deposit persists. This means, where the means mentioned above have been faithfully tried, that more animal diet is being taken than can be burned up in the system. Nature's method of warming the body is to burn up its garbage to a soluble ash, which can be readily washed out of the body. This ash is known as urea, and is so soluble that it never forms sand or gravel. If, however, the body's fuel is not perfectly consumed it forms an ash, or clinker, which cannot thus be washed away, and this clinker is the red sand (uric acid) just described.

The place where the conversion of uric acid to urea ought to take place is in the liver, next to be described; but before considering this, just a word further concerning the hygiene of the sewage of the body. It contains substances dangerous if retained in the body, for a continued failure of the kidneys to act invariably produces death with convulsions (uræmia.) Scarcely less dangerous is the retention of other refuse in the body. It is a slouchy servant who does not clean away the ashes from her kitchen stove at least once a day, and we are poor tenants if we cannot do as much for the house in which we live. Habit is second nature in this as in

many other less important matters, and those are healthiest and live longest who are scrupulous in this. Its neglect brings a bad breath, a sallow skin, headache, and loss of appetite, as it ought, for the whole body is poisoned by the re-absorption of poisonous matters that ought to have been voided from the body. But carelessness, or some seemingly more important engagement, is allowed to interfere with what ought to be as faithfully attended to as washing the hands and face, until the house of clay becomes truly filthy, and then comes a bilious attack.

And what is a so-called bilious attack? It is simply nature's house-cleaning, and fully as inconvenient as its domestic namesake. One of the duties, and in the opinion of the writer the chief duty, of the liver is to burn up, or oxidize, certain substances no longer of use in the body. One of these is uric acid, just mentioned, but if there is too much of this uric acid turned in upon the liver to be readily disposed of, the liver refuses at first to work, sulks awhile, then turns every thing upside down within us in its efforts to turn out the offending substances. This *emeute* we call a bilious attack, and it certainly efficiently accomplishes what it sets out to do; but one such strike begets another, and in a little time we find a liver prone to rebel on the slightest excuse, and thoroughly not to be depended upon. The liver is one of the worst abused and least understood organs in the body. The ancients thought its chief duty was to secrete black bile, and that black bile was synonymous with melancholy, for the Greeks believed that the soul resided in the liver, and in their language melancholy and black bile mean one and the same thing. We have learned that there are other causes for melancholy than black bile, but that there are none more efficient than a disordered liver. Whether we think life worth living depends largely upon the condition of the body's chemical works, for to such a factory the liver can be well likened.

It lies in regions 1 and 2, figured in Plate I, and, as may be seen by the annexed cut, it is abundantly supplied with

blood-vessels, so much so that the liver acts as a sort of siding into which are switched trains of both venous and arterial blood for a transfer of their freight. Much of this, gathered up by the veins from the stomach, intestines, pancreas, etc., is hurtful, and must be rapidly excreted or it will bring damage to the body. This the liver effects by working over these refuse materials in such a way that they either become harmless or are transformed into new substances of further value. Its method of disposing of uric acid has already been spoken of, and the formation of bile is an instance of the second. It is one of the triumphs of modern chemistry that it can extract from useless coal-tar carbolic acid and other valuable substances, but long before modern antiseptics were dreamed of the liver was patiently making, in bile, one of the most efficient preservatives yet discovered. But bile is more than this, for it not only prevents the decomposition of food, but also, as nature's castor oil, emulsifies fats and carries off the excess of carbon and hydrogen from the blood, thus purifying it. The failure to do this in the spring, or rather our stupidity in forcing the liver to dispose of the same amount of hydrocarbons as during the cold of winter (see page 91), brings on what is familiarly known as spring fever, for which our grandfathers were not irrationally bled. A wiser thing, however, is to eat such food (see Chapter IV) as shall not force extra work upon a liver already overtaxed with a winter's buckwheat cakes. These, like the Esquimaux' whale blub-

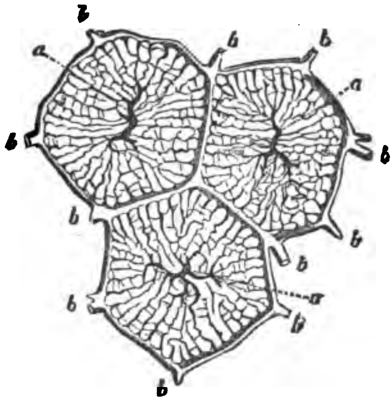


DIAGRAM OF THE CIRCULATION IN THE LOBULES OF THE LIVER.

a, a. Intralobular veins. *b, b.* Interlobular veins.

ber, are excellent fuel for the heat required during the winter, but when the spring brings a milder temperature they are as useless and harmful as it would be to keep a furnace running all summer; and worse than that, for the liver, so to speak, burns itself out in the process. It clogs like another furnace under the same mistreatment, and its unfortunate owner suffers from its smoke in the shape of a crop of boils. All this because we abuse one of the most important organs of the body, in spite of its protests in the way of headache, loss of appetite, and general lassitude, whose rational treatment has already been spoken of in Chapter IV.

Moreover, there is good reason to believe that a healthy liver is necessary to destroy certain poisonous compounds that are continually being formed in the body. This was first proven by Drs. Schiff and Lautenbach of Geneva, who found that tying the portal vein—the great vein which brings blood to the liver—in the lower animals produces a tendency to sleep, loss of sensibility in general, slowing of the pulse, stertorous respiration, and death without convulsions in a few hours. Ligation of the hepatic viens produced no such effect, wherefore Dr. Lautenbach believes that these symptons are due to the accumulation in the blood of a poisonous substance, or substances, which normally are destroyed in the liver. This is furthermore proven by the fact that blood taken from the circulation of one of the animals whose portal vein had been tied invariably produced toxic symptoms when injected into another animal; while the same animal had remained unaffected when injected with blood before the ligation of the portal vein. Schiff was unable properly to isolate the poison thus produced, but considered it volatile, and antagonistic in its action to nicotine, conia, and hyoscyamus.

More recently it has been rendered more than probable that the poison found at such times in the blood belongs to those known at the present as leucomaines. Careful experiment proves that these leucomaines are constantly being formed in the body, and unless they are neutralized invariably produce symptoms like those described by Schiff. Selmi discovered

some years ago certain poisonous alkaloids of putrefaction to which he gave the name of ptomaines. Gauthier subsequently found analogous poisonous alkaloids in the living healthy body; these he named leucomaines to distinguish them from the alkaloids of putrefaction. The leucomaines are being carefully studied in their relation to health by the French physicians, foremost among whom are M. Peter and Professor Bouchard. Gauthier thinks he has succeeded in isolating no less than five of these alkaloids from the muscular juice of the larger animals. These leucomaines, he believes, are formed in life largely by the action of oxygen. For instance, thought is attended with heat, and heat produces, according to Gauthier, in the brain neurin, an alkaloid injurious to life; muscular movements similarly form creatinine and the alkaloids mentioned above. All of the working organs of the body are now supposed to form these leucomaines; for example, according to Kossel, in the pancreas and spleen can be found adenine, derived from the cell nuclein. Adenine, when tested upon the lower animals, produces paralysis of the vasomotor system, congestion of the lungs, liver, and kidneys. The kidneys, if Bouchard's experiments can be relied upon, carry off no less than seven of these leucomaines from the body, and the remainder are destroyed in the liver, whither they are carried by the portal circulation. Some of these, or others, are doubtless excreted constantly through the skin, for the evil effects of coating it with varnish, or having it destroyed by burning, have long been known. Death in the latter cases results not from shock, but from the retention in the system of substances which are normally carried off through the skin. Life is then not merely an eddy, as Huxley describes it, but also almost a prolonged suicide, for we are constantly producing these leucomaines, and if they are not speedily removed or destroyed they produce disease and death. Health is the equilibrium between a proper production and elimination of toxic substances which are prepared within the body by the action of its own organs; disease is often due to accumulation of these

poisonous materials within the body, an auto-intoxication, as it is called (intoxication, whether from alcohol or other causes, means and is poisoning). The leucomaine poisons are derived from digestive changes in the food in the intestinal canal, and from changes within the tissues themselves. The contents of the intestines, according to Bouchard, are particularly poisonous, and their re-absorption undoubtedly produces what is known as the typhoid state or condition. Fortunately, in a sound body this rarely takes place, because of the disposition of the leucomaines, already spoken of. No wonder then that a crippled liver casts a man into gloom; but it is not the liver *per se* that depresses the entire man, but the poisons that the man has generated within himself and is unable to carry off without the liver's aid. Truly we are fearfully and wonderfully made, and nowhere is this more perfectly shown than in the daily balance between life and poisoning, through which we all hope to struggle for seventy years or more. The wonder is not that we die, but that we live at all, shut in and hemmed around by dangers seen and unseen, not the least of which are the poisons we make ourselves and invisible bacteria hereafter to be described. Perfect sewerage is the price of health, in our bodies no less than in our houses, and any deviation from this is sure to bring its penalty. In the case of the body, as in our homes, one of the surest means of suspecting that something is out of the way is the appearance of disagreeable odors. Such warning we have when the breath grows fetid, as it always does when food decomposes in the body instead of being digested. This putrefaction may take place in the stomach, but more frequently occurs lower down in the intestinal canal. The favorite location for this decomposition of food is the sigmoid flexure and descending colon, where the partially digested food is prone to lodge and by the re-absorption of the gases thus generated poison the breath. Pain and tenderness in these regions, a fetid breath, and a persistently sallow skin with constant weariness indicate this slow poisoning and call for a physician's advice, without

which the case is prone to run into an invalidism whose cause is often undreamed of. (Region IX, Plate I.)

An unpleasant breath, as has elsewhere been said, may also proceed from chronic disease of the lungs, nose, or throat; but these have other so well marked symptoms that their origin can hardly escape one's attention. That just alluded to is so remote from its cause that it often passes unsuspected. We also find in many of these cases the tonsils endeavor to do extra work, and become enlarged and show cheesy masses in their folds. This is not diphtheria, though often treated as such, but a little forced energy on the part of the glands on the surface of the tonsils to carry off poisonous substances. These cheesy excretions are very prone to decompose and poison the breath, especially of one who has the bad habit of breathing through the opened mouth instead of through the nose as nature intended. The nasal passages are especially designed to warm the air passing through them before it reaches the lungs. Indians are said to judge of a man's courage by his ability to keep his mouth shut, and possibly from them, with whom he spent many years of his life, George Catlin derived the ideas embodied in his little pamphlet, *Keep Your Mouth Shut.* It is capital reading, even yet. After many years of careful observation, among both civilized and uncivilized nations, Catlin came to the conclusion that "those who hunt about open-mouthed, like chub or trout," are never healthy nor long-lived. So important did Catlin esteem his subject that he concludes his little book in this way: "If I had a million dollars I would spend it in printing four million of my books and distributing them to four million mothers, rich and poor. I would not obtain therefor any monument or decoration of nobility, but I would have obtained the peculiarly joyful satisfaction of knowing that I had left to posterity a legacy of much higher value than money can ever have." Catlin, in the main, was right; for, to say nothing of the air of vacant stupidity imparted to the countenance from going about with the mouth half opened, the practice is positively injurious. Inhalation through the

nose warms the air and frees it from dust during its passage downward. Nor is it a matter of chance that there is so direct a passage for the air *via* the nose to the windpipe. The root of the tongue and the soft palate very materially interfere with free breathing through the mouth, while a probe carried along the floor of the nostril soon finds itself in an opening behind the soft palate and directly over the windpipe, or the tube conveying the air to the lungs. You can trace this tube down the neck with your fingers until it disappears behind the top of the breast-bone. If you were inside of it you would see that it divides there into a right and left branch, going respectively to the right and left lungs, where it branches and rebranches into the bronchial tubes (*bronchioles*), which finally end in little cells. The bronchial tubes are at first cartilaginous, or rubbery, like the windpipe; but as they descend this cartilage vanishes and the bronchioles, at last, become only soft, flexible tubes of muscle and mucous membrane. The mucous membrane of the lungs is peculiar on account of its covering of waving hairs—ciliated epithelium—which keep fanning the air in and out of these delicate tubes and air-cells (alveoli). These alveoli or air-cells (one fortieth to one seventy-fifth of an inch) look like a bunch of tiny grapes from the outside; inside they are literally little cells opening into one another, whose walls are frescoed every-where with the tints of the smallest conceivable blood-vessels. These minute vessels (capillaries) have walls thinner than the most delicate blotting-paper. Through these cell walls the exchange of gases between the blood and the air takes place under the most favorable circumstances. Gases will pass through animal membranes like water through filter paper, and in these delicate air-cells the venous blood is separated from its necessary oxygen only by this frail partition of membrane. Through this carbon-dioxide quickly finds its way and diffuses itself through the air in the lungs, while the oxygen of the air unites with the hæmoglobin of the blood, as already described (page 107), and is by it carried the round of the circulation to be

again exchanged for carbonic acid gas. Just how or where this exchange is made is not yet definitely known. It requires a more intimate knowledge of physiological chemistry than is yet possessed; for man is the modern miracle of the burning bush, which is perpetually burning and yet never consumed. The results of this combustion are invaluable to us, for upon them hang our warmth and the possibility of living at all. Without this oxidation of disused tissues we should either be swathed in unbearable fat or poisoned with leucomaines, just described. And all this is done so quietly and easily that we never stop to think any thing about what is being done unless there is an interference somewhere in the process. Chemists are acquainted with more than thirty compounds produced by the action of the oxygen of the blood on the tissues, and the failure to form any one of these disturbs more or less the whole economy of the body. Curiously enough, but three of these are ordinarily excreted by the lungs, and these form nature's soda-water, if not in exactly the same proportion as that of the shops, which contains, besides the water, only carbon-dioxide and syrup. Respiration amounts finally to the air hurrying down and paying priceless oxygen in exchange for the vilest soda-water, compounded of water, carbon dioxide, and too often flavored with onions, whisky, or tobacco. It would be a fair criticism to say that the soda-water furnished by the blood is an outrageous swindle; for there is a great deal too much dioxide for the water, and as for its syrup—pugh! To tell the truth, no sooner is the trade made than the air seems disgusted with it, and by the help of the ciliated epithelium climbs up and out of the windpipe and hurries off to the plants, which are nature's veritable old junk-men, buying up all sorts of cast-off things and paying in precious oxygen. This trading has been going on ever since the first breath of life, and for all we can see must go on until there shall be a new heaven and a new earth. The best that we can do is to see that fair play is given in both of the trades, but to do this you must keep a sharp lookout on carbon-dioxide, which will play you many a mean

trick if not well watched. Carbon, or charcoal, in its various forms, is one of our most useful possessions; but burn it and it gives rise to this colorless, transparent gas, which ought to be excluded from all decent society. But this gas finds its way in almost every-where. We use up daily about a coffee-cup of water and a bit of charcoal about the same size in making that vile mixture which was politely called soda-water, but which is really damp carbon-dioxide. It is a narcotic poison, worse than liquor; for whisky gives its poor victims at least a short period of happiness, while carbon-dioxide only stupefies and leaves him with a worse headache the next morning, or a very little more kills him. If you have any doubt of it, read some of those fearful stories of ignorance, such as that of the famous Black Hole of Calcutta, where one hundred and forty-six men were shut up in a room eighteen feet square, and in the morning one hundred and twenty-six were found dead and the larger portion of those remaining died after their release from fever contracted during that fearful night. But that is not the worst thing that carbon-dioxide ever did, for such places as the Black Hole put us on our guard; but there are thousands—principally women—who are slowly being poisoned to death by close rooms and bad air. I have often wished that this carbon-dioxide was as black as ink, so that we might know of its coming; but though it has not this cuttle-fish power, it gives no less certain warning of its coming if you will only watch for it. Drowsiness, headache, and the corpse-like smell of too many of our churches and school-rooms tell you in a most convincing way what I mean. It is not always the fault of the preacher or teacher that thoughts will wander and the head grow weary. There is more than one prayer-meeting which needs, instead of singing, "My drowsy powers, why sleep ye so? Awake my sluggish soul!" to have its sexton open the windows. Bad air is always a poison, whether found in a church or a slum, and any air becomes bad air by being breathed over and over again.

The crying sins of the modern house are its small sleeping-

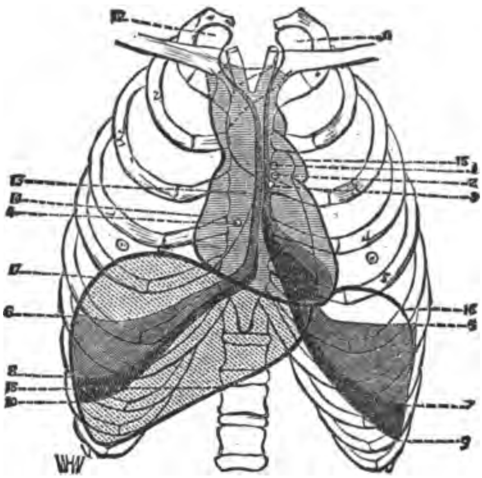
rooms and its lack of proper ventilation. The sleeping-room ought to be the largest and airiest room in the house, and preferably on the second floor, and heated, if possible, with an open grate fire. Such should always be the room selected for a run of fever or other protracted sickness; for in no other way can a room be so easily and thoroughly ventilated as by a draft of hot air up an open chimney. Failing this, two hundred and fifty to three hundred cubic feet of space should be supplied for each person in the room for the night, and provision made for removing six hundred and fifty cubic feet of vitiated air per hour. Less cubic contents per person is unsafe, and will certainly result in carbonic acid poisoning of a milder or severer type. Much of that which passes for sewer-gas poisoning is simply the result of sleeping in unventilated rooms; for Dr. Harwood says most justly on this subject: "The want of wholesome air does not manifest itself on the system imperatively; no urgent sensation being produced, like that of hunger, there is great danger of mistaking its indications. The effects of the absence of pure air are only slowly and insidiously produced, and thus too frequently are overlooked until the constitution is generally impaired and the body equally enfeebled."

The difficulties, however, in northern climates of efficiently ventilating a modern house without expensive apparatus or dangerous draughts are such that with most builders the whole subject is neglected, and the only resource left us is the window. In moderate weather a room can be well ventilated by this, by raising the lower sash an inch or so and placing beneath it a tightly fitting board. This leaves an opening between the upper and lower sash about the middle of the window, through which fair ventilation takes place without direct drafts of cold air. No thoroughly efficient and cheap method, so far as the writer is informed, of winter ventilation has yet been devised for private dwellings, although many excellent devices for larger edifices are in operation where a steam-engine and blower can be used. The best that can be done in an ordinary dwelling during the winter is to rely upon

small holes bored in the upper part of the sash into which small bent tubes or elbows pointing upward may be inserted with valves to open or shut as required. But even with these the temperature in different parts of our living rooms varies too greatly for the health of children and feeble adults. Dr. Benjamin's careful investigations show that with a temperature of seventy-five at the level of an adult's head, the floor registers only fifty degrees, and this in a well built brick house with a warmed cellar. In similar rooms the temperature at the ceiling was ninety, four feet from an ordinary window seventy, one foot from the window fifty, and at the window forty degrees. Or, in other words, a little child finds a difference of twenty-five degrees, Fahrenheit, between sitting in its mother's lap and playing on the floor, and between thirty and forty degrees from the neighborhood of the stove and the window, which is probably one of the reasons that keeping little children in bed is no small factor in their recovery from cold and the minor ailments of childhood. Thin shoes, even in the house, are dangerous experiments, for the reasons given above, and sunshine, a frequent change of rooms, and a free ventilation by opening the windows of the room just left are potent aids to long life and usefulness. Moreover, fresh air is not alone sufficient unless we learn how to properly inflate the lungs, for which purpose we must breathe deeply in whatever pure atmosphere we are placed.

Up and down the windpipe a current and return current of air need to pass fifteen to eighteen times a minute, and oftener if we are children, or if for any reason respiration is imperfectly done. "As easy as breathing" is a frequent simile, but a sufferer from asthma or pneumonia tells a very different story. With them existence requires a terrible struggle with asphyxia—the doctor's term for a lack of air and its resulting imperfect aeration of the blood, previously described in this chapter. This aeration requires, in addition to the nose and windpipe, the aid of the lungs, which are continuous with the windpipe, and are inclosed each in a tough, closed sac, known as the pleura (plural

pluræ). The two pleuræ, as may be seen from the annexed cut, do not meet except at one point in front. This leaves an interspace between them, called the mediastinum, and in this mediastinum are held all of the viscera of the thorax ex-

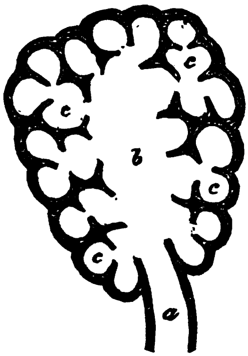


cept the lungs. In the cavity of the pleuræ we find the lungs, which extend from one to one and a half inches above the collar bones to the diaphragm, or from the root of the neck to the sixth and seventh ribs. The broad concave bases of the lungs rest upon the convex surface of the diaphragm, the thin lower edges of the lungs fitting accurately into the wedge-like space between the ribs and the diaphragm. The lungs are of unequal size, somewhat conical in shape, and lie in the right and left sides of the thorax respectively, the base of the right lung being considerably hollowed out by the bulging upward of the liver, which projects upward as far as the fifth rib; the base of the left lung is also concave, though to a less degree, by the upward projection of the stomach, spleen, and left lobe of the liver. The right lung is somewhat larger and broader, owing to the location of the heart. The right lung weighs about two ounces more than the left

lung, and is nearly two inches shorter than the left, owing to the projection upward of the liver upon that side. The right lung has three lobes, the left two, and both lungs hang suspended in the thoracic cavity by what is known as the root of the lungs. This root is a collection of blood-vessels and the trachea, sending a branch to each lung composed of a bronchial tube, pulmonary artery, bronchial arteries and veins, and the pulmonary nerves, lymphatics, and glands inclosed in a reflection of the pleura. The weight of the lungs is about forty ounces, and their color at birth is pinkish, but they grow darker with age, so that the lungs of an adult are slate-colored, or even darker. Lung tissue is so light and spongy that when it is inflated it floats on water, and crackles when handled, owing to the air in the interstices of its lobules. Each of these lobules contains one of the branches of the bronchial tubes with its terminal air-cells, vessels, and fibrous tissue holding them together. These air-cells are blind pouches in which the subdivisions of the bronchi terminate, and it will be remembered that the bronchi are branches or prolongations of the windpipe, which, under the name of the main bronchus, enters the lungs and divides and subdivides into smaller bronchi, right and left, until, as has been said, each of these bronchioles terminates in an air-cell, or alveolus, as it is sometimes called.

The form of these air-cells is well shown on the following page, which gives a cross-section of one of the ultimate bronchioles and its terminal vesicles. Each of these is held in a network of capillaries, which inclose each alveolus of the lungs in a sort of basketwork of blood-vessels. Each air-cell measures about one seventy-fifth of an inch in diameter, but as there are estimated to be eighteen million of these air-cells their combined surface amounts to more than two hundred square yards, or more than fifty times the extent of the surface of the body. Through this thin film of tissue, exposed to the air on both sides, the entire amount of blood in the body flows three times in a minute, requiring for its aeration twelve thousand quarts of air daily, which must be

breathed in and out daily to keep the body properly ventilated. This is accomplished by inspiration and expiration, as it is called; for breathing, simple as it seems, is a complex act composed of breathing in, breathing out, and resting; for the lungs, like the heart, must have an interval for rest. Each inspiration ought to draw into the lungs thirty cubic inches of fresh air, and each expiration ought to send out about the same amount, although not the identical air just breathed in; for we never force out all of the air contained in the lungs. The average capacity of the lungs may be set at two hundred and thirty cubic inches of air; thirty may be driven out by an ordinary expiration, so that at the close of expiration there should be two hundred cubic inches in the lungs. The thirty cubic inches that flows to and fro is known as tidal air; the two hundred cubic inches is divided into what is known as residual air (one hundred to seventy-five cubic inches), which cannot be driven out by any force on our part, and about an equal amount that is known as supplemental air, or that which ordinarily remains in the lungs, although it can be driven out by forced expiration. The two hundred cubic inches of residual and supplementary air are those which are left in the lungs after expiration. Add to this the thirty cubic inches of tidal air drawn in by inspiration, and we find two hundred and thirty inches within us at the close of an ordinary inspiration.



Air cell (*b*), alveoli (*c*), and bronchiole (*a*).

Now two hundred and thirty cubic inches of air uncomfortably distend the lungs, so we ease them by expiring, or squeezing out, about thirty cubic inches of impure air, for only one seventh of all the air that is in the lungs is changed at each breath. The remaining two hundred inches aerate the blood, while the thirty cubic inches of tidal air hur-

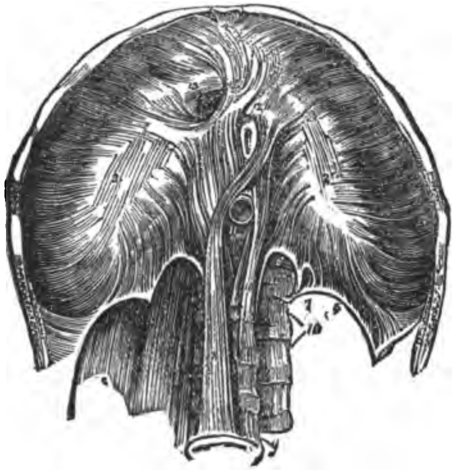
rying up and down the throat, may be considered the fresh recruits and returning on sick leave being carried away to be refreshed, then hurrying back to relieve the two hundred cubic inches of air which stand between us and death; for asphyxia results if fresh air is not speedily brought to their relief. In addition to the two hundred and thirty cubic inches of air—tidal, residual, and supplemental—in times of emergency seventy-five to one hundred cubic inches more may be forced in temporarily. This is known as complemental air, and is invaluable to the gasping asthmatic or the sufferer in the last stages of chronic heart trouble.

The importance of early increasing the amount of the supplemental air that can be taken into the lungs can hardly be overestimated. Writing and studying at a desk or table so inevitably tend to round the shoulders and hollow the chest that some method of counteracting this should be systematically adopted. Indian clubs, an inhaling tube, dumb-bells, and mountain climbing, when possible, will do wonders in this direction. Singing, under a competent teacher, also does much to expand the chest, and if half the attention were given to the development and care of the lungs which is given to the hair, consumption might be nearly eradicated, instead of causing nearly a fifth of all the deaths of adults in this country. A sunless, unventilated house will certainly germinate the seeds of the disease whenever they are latent, or, if the bacterial theories of tuberculosis are correct, prepare a suitable ground in which the bacillus tuberculosis (see Chapter VIII) will increase and multiply, until the consumptive is worn out in a vain effort to expel them by coughing. And what is a cough? It is nature's way of clearing out the windpipe; really only a spasmodic expiration. For instance, instead of the normal inspiration and expiration, when we cough we first draw in a deep inspiration—these are the few seconds of blissful uncertainty of whether you are going to or not which usually precede a cough or a sneeze—but the glottis closes while something tickles a nerve, say in the larynx, which grows rebellious, and instead of giving us time

for a well regulated expiration, with a spasm it forces the air back through the glottis with a rush that carries the offending crumb or mucus before it; if not, the process is repeated as long as necessary. Sneezing is essentially the same, except that in sneezing the trouble is in the nose; so instead of the air being forced out from the mouth, the soft palate and the back of the tongue come together and force the air out with a "chee-chee" through half-closed teeth and nose.

Sighing is a prolonged inspiration, and, when not due to first love, like yawning is a proof of bad air or an exhausted nervous system. Yawning differs from sighing in that its prolonged inspiration is followed by a prolonged expiration, both of which are largely involuntary. Snoring is a flapping to and fro of the soft palate during sleep. With some the sound occurs only during inspiration, with others during both inspiration and expiration, and takes place during very profound sleep, or in those whose nervous control over the parts has been lessened. Laughing and sobbing are physiologically the same, for they are both spasmodic inspiration and expiration, and hence the ease with which the practiced orator will carry his auditors from one to the other. Hiccough is also a spasmodic expiration due to a spasm of the diaphragm, or the great fan-shaped muscle which divides the trunk of the body into the thoracic and abdominal cavities. Its front edge is attached to the breast-bone, and its sides slope downward and are fastened to the lower six ribs. The diaphragm, therefore, does not form a horizontal partition, but arches upward in shape not unlike a policeman's helmet; but unlike that in that it is not stiff, but exceedingly flexible, changing its position with every inspiration and expiration. It is *par excellence* the muscle of respiration, assisting it like the flexible side of a pair of bellows. (See cut, page 40). Gaseous distension of the stomach may press upon the diaphragm so as to be mistaken for heart disease. Fasting relieves this trouble in short order, while it will aggravate real cases of heart trouble, for which it is often mistaken. The diaphragm may be even ruptured by distension, as happened in the

following unique case, reported some years ago by Dr. Brenner, of a man who actually split his diaphragm in two, and



Cut showing diaphragm from its lower side, and openings through which pass the vena cava (13), esophagus (12), and aorta (11).

died from eating four plates of potato soup, "numerous" cups of tea and milk, followed by a large dose of bicarbonate of soda to aid digestion. His stomach swelled enormously, and tore the diaphragm on the right side, causing immediate death.

But if the diaphragm is at times a source of danger, it is, on the other hand, invaluable for breathing and laughter. The real value of the latter to the body is that, as says another, "probably there is not a remote corner or little inlet of the minute blood-vessels of the body that does not feel some wavelet from the great convulsion produced by hearty laughter shaking the central man. The blood moves more, it conveys a different impression to all the organs of the body, as it visits them on that particular mystic journey, when the man is laughing, from what it does at other times. And thus it is that a good laugh lengthens a man's life by conveying a distinct and additional stimulus to the vital

forces. The time may come when physicians, attending more closely than they do now to the innumerable subtle influences which the soul exerts upon its tenement of clay, shall prescribe to a torpid patient 'so many peals of laughter, to be undergone at such and such a time,' just as they do that far more objectionable prescription—a pill, or an electric or galvanic shock; and shall study the best and most effective method of producing the required effect in each patient."

DIAGRAM OF HEART AND CIRCULATION (PLATE II).

a. a. Vena cava, inferior and superior.

r. a. Right auricle with orifices of the venæ cavæ emptying into it.

t. v. Tricuspid valve, closing orifice between right auricle and ventricle of heart.

r. v. Right ventricle of heart.

p. a. o. Orifice of pulmonary artery.

p. a. Right and left pulmonary arteries.

p. v. Pulmonary veins, arising from the lungs and emptying by four orifices into the left auricle.

l. a. Left auricle.

m. v. Mitral valve, closing orifice between left auricle and left ventricle.

l. v. Left ventricle.

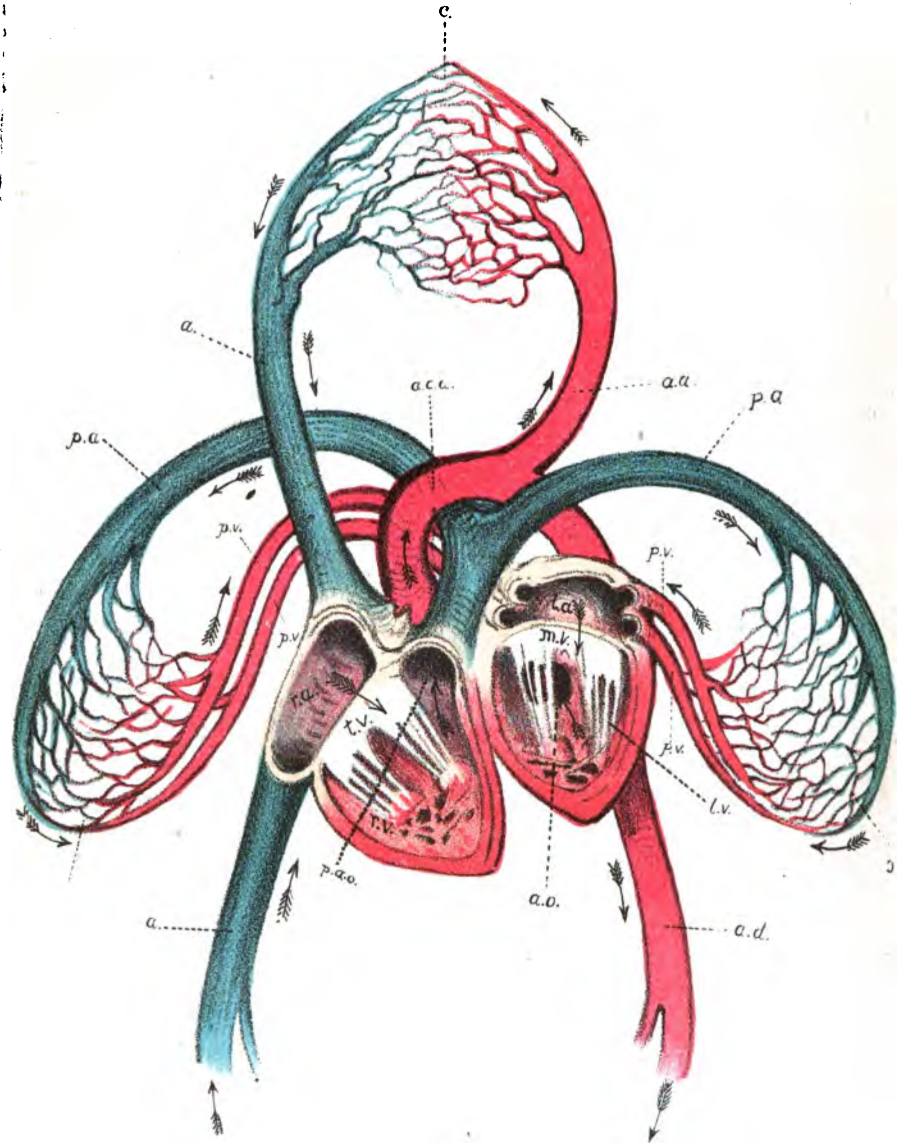
a. o. Aortic orifice.

a. o. a. Arch of the aorta.

a. a. Ascending aorta.

a. d. Descending aorta, at last communicating by capillaries with the inferior vena cava, though this communication is not shown in the plate, as in the case of the ascending aorta.

N. B. The course of the blood is shown by the arrows in the diagram, its color indicating whether it is arterial or venous.


c.
a.
a.a
a.c.a.
p.a
p.a
p.v.
p.v.
p.v
r.a.
t.v.
l.a
m.v.
r.v.
p.a.o.
p.v.
l.v.
a.o.
a.
a.d.

CHAPTER VI.

THE DAUGHTERS OF MUSIC, AND THEY THAT LOOK OUT AT THE WINDOWS.

THE diaphragm, in addition to its duties described in the preceding chapter, greatly assists speech, the most precious of all of man's accomplishments. The means by which this is done was poetically described in *Punch* many years ago as follows:

> "The pharynx now goes up,
> The larynx, with a slam,
> Ejects a note from out the throat,
> Pushed by the diaphragm"—

a jingle that may better serve to fix the order of events in speech than a more technical description of speaking, or singing; which differs one from the other mainly in the aid furnished by the lips and the tongue in speaking.

Lips were made for other purposes than merely to be kissed; and in fact they are kissed too often for peace and safety, especially in the case of little children, who apparently have no rights in this matter that adults feel bound to respect. A kiss in Iceland, even if the lady consents, is punished with a fine sufficient to furnish a whole ship's crew with pilot jackets, and a similar or heavier penalty ought to be laid upon the promiscuous kissing of babies, and ladies among themselves. It is a foolish and nonsensical practice, and worse than that, dangerous, for diphtheria and worse diseases are thus carried about a community to the perplexity of the doctor and the dismay of his patient. Diphtheria is often, if not usually, communicated in this way, from what is supposed to be a simple sore throat. As competent authorities as Drs. Pepper and Jacobi believe that there are more cases

of mild diphtheria out of bed than in, and that the severer forms of the disease may be produced from these mild cases. The possibility of this ought to put an end to the indiscriminate kissing of babies, for, as it was recently well put in the *Scientific American*, "The children will not suffer if they go unkissed; and their friends ought for their sake to forego the luxury. A single kiss has been known to infect a family; and the most careful may be in a condition to communicate the disease without knowing it. Beware, then, of playing Judas to the little ones."

But osculation is not the only use to which lips can be put. Their sense of touch is so delicate that the blind have been able to read by moving their lips to and fro over an embossed page. The chief use, however, of the lips aside from their assistance in eating is the part that they play in speech. Certain of the letters are known as labials, for the reason that they are formed by the lips, and many others cannot be formed without their aid. For instance, the same expiration may be made to sound either e, a, or o, according to the position of the lips. L, r, f, and v sounds are made by the tongue and lips jointly, and whispering is the voice produced by the vibration of the muscular walls of the lips, or, as Huxley puts it, a whisper is in fact a very low whistle. The wild beast of the mouth, which, according to St. James, is untamable —"For every kind of beasts, and of birds, and of serpents, and of things in the sea, is tamed, and hath been tamed of mankind: but the tongue can no man tame"—usually gets the blame of speech; but the fact is that the tongue is really the least important organ in speaking, and has nothing to do with voice at all. The distinction between the two is that voice is the sound produced by the vibration of elastic cords; speech is this sound modified by the throat, tongue, and lips. Voice is the music produced by the pipe-organ of the throat, while speech is its notes modified by the sounding-board of the pharynx and the various shapes the cavity of the mouth can be made to assume; many and various in that

amazing "ready, spontaneous, automatic, self-sustaining flow of speech peculiar to our sisters, in which each develops her proposition without the slightest regard to what the other is saying." (O. W. Holmes.)

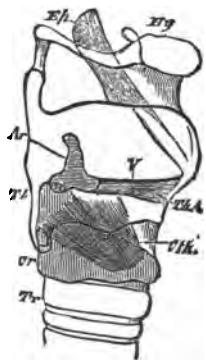
But, useful as is the tongue, it is not absolutely indispensable for talking. We shall see hereafter that the larynx plays the major part in speech. Huxley gives a long account of a man who had his tongue cut off clear back to the soft palate and yet was able to talk fluently, and pronounce all letters except t, d, m, s, and p, which were strangely changed into other consonant sounds; thus, tin was fin; dog, thog; cat, catf; big, pig; tack, fack or pack; dine, vine; mad, madf; tool, pool; do, thew; goose, gooth, etc.

So that cutting out the tongue might no more cure a gossip than the pilgrim fathers' remedy of the ducking-stool. But extirpating her tongue would ruin her enjoyment of her neighbor's preserves, for the sense of taste is located in the mucous membrane of the tongue, especially in its back part. Much of that which passes for taste is really smell, for it is the odor of food which makes the mouth water. The tongue, like the fingers, has papillæ, or ridges, scattered over it varying in shape according to their location and duties. Three forms of these are known, namely, filiform, fungiform, and circumvallate. The filiform are long and pointed, and probably do little more than roughen the tongue, and thus help it to move the food hither and thither. In the calf these are almost spines, as you have appreciated if you ever happened to get your hand into its mouth when you were feeding "bossy" salt. These are the papillæ which when coated give your tongue its furred look. (See Chapter I, page 18.) The fungiform (club-shaped) papillæ are found here and there over the front of the tongue, while the fortified or circumvallate are arranged in the shape of the letter V at the base of the tongue. These latter are the chief organs of taste; but just how these little knobs tell us that sugar is sweet and vinegar is sour is more than at present is known, except that it must be done through the filaments of the nerves which cluster over them. We

are very apt to confound smell with taste, so that mothers do a very sensible and physiological thing when they hold Johnnie's nose to make him take the luscious castor oil. If she could only keep her fingers there all day it would be all right; but when they are removed, then comes that awful corpse-like taste which must be known to be appreciated, and yet doubtless the Esquimaux, who guzzle train oil, would smack their lips over a bottle of "cold pressed." A Russian peasant would turn up his nose at the American idol, "pie," but feast like a king on raw whisky and tallow candles, and even our refined French brethren go into ecstasies over a dish of fried frogs or squirming snails. One man's meat is another's poison. There are whole families who have a horror of cheese. Some people cannot even take a homeopathic globule of mutton. There are well authenticated cases on record of gout always following fish, fearful sickness from eating strawberries, and many similar cases in regard to shellfish. Strange as these may seem, we must leave them with the thought that they are no stranger than many other peculiarities that we inherit from our parents.

If it be true, as some most excellent people assert, that we ought to pay no more attention to the food we are eating than if we were shoveling coal into a furnace, too much time has been spent on this matter of taste. So let us proceed past the soft palate, which hangs as a curtain before the pharynx, or the cavity at the top of the throat. The use of the soft palate is to prevent water and food from passing into the nostrils, which it closes as it is forced up in swallowing. Behind this palate curtain we find a little triangular room called the pharynx, from which we can either go up stairs by way of the skylights opening into the nostrils, or down stairs *via* either the windpipe or esophagus. The last-named route takes into the kitchen and dining-room, already visited (see Chapter IV); the former leads into the larynx, which different routes were evidently unknown to the school-boy who wrote: "A throat is convenient to have, especially for ministers and roosters. The one eats corn and crows with it; the other preaches

through hisn and ties it up." If the young author had, however, taken his stand before a looking-glass and pushed down the root of his tongue as far as possible, at the same time uttering the sound a-a, he could have seen why food and preaching do not travel the same route. At the top of the windpipe with a good light may be seen a yellowish-white leaf-like body—the epiglottis—moving to and fro with every inspiration and expiration and shutting down like a trap-door, or bridge, over which the food passes when we swallow. The larynx is essentially a triangular cartilaginous box, flattened behind and at the sides, while in front it forms a vertical ridge—named Adam's apple, in memory of Eve's gift, the core of which is fabled to have stuck at this point. This larynx box is hung on a V-shaped bone and consists of nine cartilages, the largest of which is named the shield, or thyroid, cartilage, from its shape. On its lower edge it is joined to another, the cricoid, or seal ring, cartilage, whose seal being placed behind leaves a gap in front filled in only with membrane. By the aid of a laryngoscopic mirror, properly held in the throat, we may see, if we are curiously inclined, on the upper and back part of the seal-ring cartilage fastened two curly cartilaginous bits, known as the funnel (arytenoid) cartilages, to which are fastened tiny muscles to pull these funnel cartilages together or apart.



TRACHEA AND LARYNX.
Ep. Epiglottis. *Cr.* Cricoid.

Just below these cartilages are the vocal chords proper, which correspond to the strings of a violin, of which the human pharynx represents the body, or sounding-board, for a violin more nearly resembles a human voice in its tones than any other musical instrument. Musically speaking, the human vocal apparatus is a combination of a reed-organ and the violin, of which the trachea is the pipe, and the pharynx and the nasal cavities the body of the violin, whose

strings are in the larynx, which we have seen is placed below the epiglottis in the windpipe. These violin strings are known to the anatomist as vocal cords, but when we speak of them as such please drive out of your mind any idea that they look at all like violin strings or wrapping cords. On the contrary, if you ever have the opportunity to look with a small mirror (laryngoscope) properly held over the larynx, you will find the windpipe just below the epiglottis nearly closed by two, pale reddish projections, or swellings, on its inner surface. These do not completely come together, but leave a V-shaped opening between them. With an attempt to say Ah-ā you will find these edges become nearly parallel, the chink narrower, and its thin edges vibrate from the current of air set in motion below from the lungs outward. The principle is that of the blade of grass held between our thumbs which we blow upon to make squeak. Put two blades of grass at a slight angle between your thumbs and you have, except in color, a very fair working model of the human vocal cords in repose. The size, shape, and relative position of the blades of grass are about those of a human glottis, or the apparatus by which we sing and talk. The sound produced by this grassy musical instrument is caused by the vibrations produced in the grass by the motion of the air blown upon it. These vibrations start waves of sound, and upon the frequency of these depends the pitch of our musical instrument—if we may so call the grass between our thumbs. In exactly the same way the human larynx is made to produce sounds by the passage of the air from the lungs outward. When the chords are separated so as to form a V-shaped chink the air passes quietly in and out without giving rise to any sounds; but when the chords are drawn parallel and their free edges put upon the stretch, the passage of the breath through this narrow opening causes its edges to vibrate, just as it did with the blades of grass, or as does the reed in a pipe-organ, and similarly produces audible sounds, or sound waves, upon which they depend; for all sounds depend upon vibrations of varying rapidity. If they

are irregular and of uncertain intervals we call the result a noise, but if these vibrations come with regularity we produce what is known as a musical note. This may be proven by holding a card against a toothed-wheel slowly rotating. If struck irregularly it makes only a noise, and so long as the wheel turns slowly we can distinguish between these separate noises, or in other words the vibration of the card is so transient and irregular that it fails to produce the regularity in vibration necessary to make a musical note. Turn the wheel faster, and hold the card against the teeth, and the whole character of the sound changes. It becomes continuous and musical, and as the machine revolves faster and faster, the pitch of the sound is heightened to a shriek, and then becomes inaudible, or in other words the vibrations may become so rapid as to fail to make an impression upon the auditory nerves, which can hear sound vibrations only between certain limits. The exact number of sound waves necessary to próduce any given note has been accurately counted, and by a proper instrument giving these vibrations any given note can be reproduced. Now the number of these vibrations depends upon the length and tension of the string vibrating, and all this is regulated in our throats by the action of the tiny muscles guiding the vocal cords. The quality of a voice—bass, tenor, etc.—depends upon the relative shape of the larynx, and hence the different quality of male and female voices, and the inability of the gentler sex to sing bass. The range of a voice depends upon the difference of tension to which the vocal chords can be subjected, and accuracy in singing depends upon our ability to adjust this tension to any point desired. No amount of training can give a man, or a woman, longer or shorter vocal cords, and hence we cannot greatly vary the natural range of voice; but education is all-essential to accuracy in singing. The differences of adjustment in the vocal cords are so slight and so delicate that those who cannot sing are lost in wonder, love and praise in the presence of an artist such as Catilani, whose voice is said to have been accurate to a register of

three octaves, while their own voices can accomplish only three notes, and cannot certainly be depended upon for even those; or, still worse, like the unfortunate boy, may get the credit for Sunday wood-sawing when only holding a private praise service in the barn.

Speech, as has already been said, depends upon the modification in the sounds produced by the vibrations of the vocal cords by the cavities of the nose and mouth. This was clearly demonstrated by Professor Roód, of New York, in his popular lectures on the voice, in which he shows a serviceable set of vocal cords made from a sheet of rubber. These by blowing through them will howl most dismally; then by placing this sheet of rubber in different shaped pipes, through which air is forced by a bellows, it can be made to utter very distinct sounds, and even cry out Pa-pa in a way that would call a loving father out of bed on the coldest winter night. The French dolls that say Ma-ma when squeezed are made on the same principle. Professor Kemplon, of Vienna, has further practically applied the principle so that he has invented a machine which speaks not only syllables, but whole words and sentences. A Mr. Faber has done still better, having invented a singing machine which runs up and down the scale; and perhaps the time will come when the church will order a choir of these along with their organ, and thus put an end to those everlasting squabbles which make miserable the life of the music committee—unless Dr. Tourjée brings in the millennium by congregational singing before that time. All these artificial singing and talking machines are, however, cumbersome and intricate compared with ours, which is held in a space hardly larger than your two thumbs. It is, to be sure, a single pipe-organ, but Von Kamper has proven that with a single pipe only fourteen stops are necessary for speech; namely, those representing the vowels and l, r, w, f, s, b, d, g, sch, which by the aid of the tongue, lips, and lungs can give forth an almost infinite variety of sounds. According to Scripture, our voices ought to be as "one who playeth well on an in-

strument," or "as a very lovely song of one that hath a pleasant voice," for there is no music so sweet as a properly modulated, human voice. Unfortunately, in this country the vocal chords seem to be generally out of tune, for the harsh, shrill, nasal American voice is the butt of the civilized stage. There is an intenseness and a "concert pitch" to the voice of the average American young lady that goes through the ears of an educated foreigner like a knife, for there is a softness and gentle modulation to the feminine voice abroad that is exceedingly enjoyable. The shrillness of the average American voice is due in part to habit, for its high pitch can be lowered by carefulness, but its original cause may be found in the dryness of our climate as compared with Europe. We have, it is true, as large a rainfall, but the wind springs up as soon as the rain is over, and dries out the moisture from the atmosphere, so that cabinet work made on the other side of the water soon drops to pieces in America. This quality in the atmosphere tends to beget a restlessness which never fails to attract the attention of a foreigner. The same cause produces nasal catarrh, so frequent in this country, and sooner or later affects the quality of the voice also. Possibly the presence of ozone in our atmosphere has also something to do with the *timbre* of the American voice, for experiments recently carried on in Paris show that the inhalation of various volatile substances will change the quality of the human voice. Dr. Sandras found that he could in this way produce the characteristic voice of the drunkard and remove it temporarily at will, as well as alter the pitch of the voice and its range also. "Tar-water, alcohol, ether, and the oils employed for this purpose are not new; it is only their application which may be said to be novel. The most curious part of the experiments is the accuracy with which certain well-defined effects are said to be obtained. Thus, a certain number of inhalations of one kind will diminish the compass by so many notes, while another will confer an additional eight or ten; some even limit the range to five or six notes."

It is claimed by some that the quality of the Italian voice is due to the presence of ammonia in the air of Italy, and an enterprising Yankee has actually invented and patented an ammoniaphone, which it is hoped will transform the native harshness of the American voice to the sweetness of a Patti's. Speed the day! but, as his progress as yet seems discouragingly slow, the best thing that can be done in the interval is to use the voice naturally and give it a fair opportunity to work untrammeled. Tight collars have more to do with clergymen's sore throats than continuous speaking, provided the voice be used in natural speaking, not preaching, with its artificial intonations. During public speaking the neck expands an inch or more, from the surplus of blood required for the brain and vocal cords. At such a time an ordinary collar becomes too tight, and congests the throat and neck and head so that the unconventional circuit rider of the earlier day would, as he spoke, divest himself of cravat and collar and speak at his best with bared neck.

"Women," says H. L. Hastings, "go with their necks bare and men keep theirs swathed and bandaged, and ten women have sweet voices where one man has one. A man's voice should be as pure as a woman's. Why is it not? He is shaved and choked. God has provided a covering for man's throat—light and soft, it clothes the neck and preserves the health; but a man gets a sharp iron, scrapes his neck, ties a rag around it, takes cold, has sore throat, bronchitis, and consumption, and dies." Or if it does not come to that he finds himself afflicted with a chronic sore throat and a perpetual sniffing and hawking, which makes him an easy prey to all of the brethren "late in the ministry" who have a sure cure for catarrh. Loose collars, frequent bathing of the neck with cold water, and the exercise of care to avoid getting chilled will do more for the radical cure of catarrh than all the inhalers ever advertised, unless the congestion of the nose has proceeded to chronic disease of the turbinated bones.

These are two scroll-shaped bones, situated at the back of the nose, very light and spongy, because filled with cavities which communicate with the interior of the nose, and are lined with the same mucous membrane (ciliated). Above and to the front of these turbinated bones, about on the level with the upper part of the nose, is a delicate perforated plate of bone (cribriform) through which the olfactory nerve sends innumerable filaments to the mucous membrane of this and the surrounding parts of the nose. By these we are enabled to smell, a faculty which requires that the air containing the odorous particles must find its way up the nose to the cribriform plate, and there make its impression upon the terminal fibers of the olfactory nerve. These odors may pass directly up from the mouth or through the nostrils, where the process is assisted by sniffing, or drawing by a sudden inspiration, these odoriferous particles further up into the nose. If, however, the turbinated bones are swollen, as takes place in recent colds or chronic catarrh, the passage upward of the fragrant air is impeded and the sense of smell is either partially or entirely lost.

The organs of smell are not as fully developed in man as in some of the lower animals, notably insects and certain fishes; the shark, for instance, having no less than twelve square feet of olfactory organs. The faculty of scent may be cultivated like all other faculties, as is proven by bloodhounds and breeds of dogs which have been especially trained in this direction until it becomes an hereditary faculty. Those who deal in teas, coffees, perfumes, wine, and butter often cultivate their powers to a wonderful degree in their especial lines, but with the majority of people it is the least cultivated of the senses, although O. W. Holmes thinks it the one which most powerfully appeals to memory. Professor Valentine has recently tested the delicacy of the sense of smell in regard to various odorous substances, and found "that a current of air containing 1–30,000 milligram of bromine, or 1–500,000 milligram of sulphureted hydrogen, or 1–2,000,000 milligram of oil of roses can be perceived by

the sense of smell. He also determined that the amount of odoriferous air which must pass over the olfactory membrane in order to excite the sense of smell was from 50 to 100 cubic centimeters (one tenth to one fifth of a pint). He calculated, therefore, that the actual amount of bromine necessary to excite a sense of smell was 1–600 milligram; of sulphureted hydrogen, 1–5,000 milligram; of oil of roses, 1–20,000 milligram (about 1–120,000 of a grain). Two recent experimenters, E. Fischer and F. Pentzoldt, of Erlangen, have found two other substances which far exceed the foregoing in their capacity for affecting the olfactory nerves. These were mercaptan (sulphureted alcohol) and chlorphenol. They found that in air containing 1–230,000,000 milligram to the cubic centimeter of chlorphenol, and 1–23,000,000,000 milligram of mercaptan, these substances can be appreciated, and it was estimated that only 1–4,600,000 milligram of chlorphenol and 1–460,000,000 milligram of mercaptan is necessary to excite a sensation of smell. There exists, therefore, a substance which in so small a subdivision as 1–2,760,000,000 grain, or not far from one three-billionth of a grain, is capable of calling out a nerve impulse. This subdivision of matter is quite beyond comprehension, yet the nose alone can appreciate it. The smallest subdivision appreciable by the eye through the spectroscope is 1–1,400,000 milligram of sodium, which is a 250 times coarser division of matter than the minimum of odor-exciting mercaptan."

Contrary to general belief, the sense of smell is more acute in man than in woman, for the experiments of Nicolls and Bailey have proved this beyond a reasonable doubt. Their experiments were made by means of a series of solutions of oil of cloves, extract of garlic, and prussic acid, which were successively diluted and then submitted to a number of persons of both sexes in order to classify properly their sense of smelling. The result showed conclusively that the sense of smell was generally much more delicate in males than in females, but that the degree of acuteness had a wide individual variation; thus some were able to detect one part of

prussic acid to two million parts of water, a dilution too weak to be detected by any chemical test, while others of both sexes were unable to detect prussic acid in solutions of dangerous strength.

While it is possible for disease to be introduced into the system through the nasal organs, as a rule they are our best protection against toxic vapors. Doubtless the sense of smell becomes weary by continued exposure to unpleasant odors, but fortunately most of these are disagreeable rather than dangerous. With rare exception those employed at work in the rank odors of a fertilizing factory or a fish-rendering establishment enjoy comparatively good health, provided respiration is carried on through the nose. It may even be fairly questioned whether the perfume of flowers is not as mischievous as those from such factories. Says a recent writer on this subject, "The odors of flowers in a closed chamber of limited space, especially during the night, manifest themselves by serious disorders, such as headache, syncope, and even by asphyxia, if their action is too prolonged. In nervous persons numbness may occur in all the members, convulsions, and loss of voice; but in general only a state of somnolence, accompanied by feebleness and retardation of the action of the heart. This state is often associated with well-marked dimness of vision. Among the flowers that are most deleterious may be mentioned the lily, hyacinth, narcissus, crocus, rose, carnation, honeysuckle, jasmine, violet, elder, etc. In addition to the danger caused by their smell should be mentioned their action on the air. During the night flowers actively produce carbonic acid, which is injurious to health. Majendie cites a case of death caused by a large bouquet of lilies which the sufferer, a previously healthy woman, allowed to remain in her bed-room while she slept. Among the more dangerous plants may be mentioned the walnut, the bay-tree, and the hemp. The action of these is well known, the latter, indeed, producing a kind of drunkenness. Certain drugs may even produce death by the inhalation of their vapors only; noticeable among these are the so-called anæsthetic

vapors, prussic and osmic acid. At a session of the French Academy of Sciences, some years ago, a noted French chemist presented to that body a small tin box containing, according to his statement, enough osmic acid to kill every inhabitant of the city of Paris provided the package was broken. The sense of smell is sometimes so intensified that with certain persons it produces the effects of intoxication, so that Pope's lines.

"Die of a rose in aromatic pain
By swift effluvia darting through the brain,"

was almost realized in the case of Grebry, the composer, and Anne of Austria, upon whom the odor of roses produced poisonous effects. There is also on record a well-authenticated case of a man falling down in strong convulsions at the smell of mutton, and the writer is personally acquainted with cases where intense nausea is produced whenever a cat is admitted into the room, and another where similar effects are produced by the odor of caraway seeds. Handling ipecac with many druggists produces attacks closely resembling hay fever, which by the way is now generally believed to be excited by the microscopic pollen of certain weeds floating in the air. *Per contra,* Hahnemann, during the last years of his life, taught that all diseases could be cured by olfaction, or the smelling of certain medicated sugar globules. Unfortunately, his hopes have not been realized, and the nose serves us only as an organ for the enjoyment of sweet odors and the utilization of pocket-handkerchiefs.

The reason why it was necessary, as says the old song, for Nancy "to wipe her apron with the corner of her eye" when the sad news of her true lover's death came is that just there, on the outer side of the eye, the tear-factory, or the lachrymal gland, is situated. On the outer and upper margin of the eye we find this gland, which is about the size of an almond, kept constantly at work pouring out its fluid and spreading it by means of seven minute canals over the surface of the eye. Thus the eye is kept bathed and freed from dust, and so important is this work done by the lachrymal gland

that if, for any reason, it is unable to perform its duty the eye grows opaque and loses its sight; so that all are not "tears, idle tears," though there must have been many such in Rome, if the Roman ladies ever filled the "tear jugs" which are found there in almost every tomb. Ours are disposed of in a much less romantic way. If there are too many for the eye to hold comfortably they trickle over the lids down the cheeks; but ordinarily they find their way out by means of a couple of little passages of their own into the nose. If you will turn down the lid you will find near its inner corner a little black spot on its inner margin. Now, if you had a very fine silver probe you would find that it would enter a little canal, and, by some dexterous turnings, you could at last bring out this probe near the floor of the nostrils, and this is the course that the tears usually take; hence the sudden desire for a pocket-handkerchief when our feelings begin to melt.

Retracing our steps, let us return to what the poets call "the curtained windows of the ivory palace of the soul." This is poetical. Facts are better expressed by saying that the eye is an optical instrument admirably adapted for the use of "those that look out at the windows." We find it amply protected from injury by the fluids already spoken of, the eyelids, and the eyebrows. The latter act as a screen, or as the gutters on a roof, to turn aside fluid or dust which otherwise might find its way into the eye. The eyebrows furthermore contain several small muscles, which act both voluntarily and involuntarily to protect the eyes from harm by narrowing the opening over them. This is more perfectly accomplished by means of the eyelids, which are two movable shutters made to close at will over the eye. The rapid involuntary motion of these constitutes winking, which is designed by the aid of the eyelashes to beat back insects or dust which would otherwise find their way into the eye proper. This, known as the eyeball, is a round body a little more than an inch in diameter, made up of several layers or coatings, and securely lodged in its own bony chamber or orbit. In the

back part of the orbit we find an opening through which the optic nerve passes down from the brain and perforates the back part of the eye a little to the inner side, where it spreads out at the back of the eyeball through a thin membrane called the retina. This is at no point more than one eightieth of an inch in thickness, and represents the sensitive plate used in a photographer's shop. The retina is sometimes called the third coat, or tunic, of the eye, resting behind on the choroid, or second coat, hereafter to be described, and in front lying in immediate contact with a jelly-like fluid known as the vitreous humor. The retina itself, then, is an exceedingly delicate membrane, which, under the microscope, can be divided into several distinct layers. At its back, that is, nearest to the orbit, are nerve fibers and corpuscles. (See Chapter VIII). Above this we find what has been called the layer of rods and cones, minute, rod-like, and conical bodies standing perpendicularly to the plane of the retina. These rods and cones occupy the anterior quarter of the retina, standing above the connective tissue which binds it to the choroid, and placing the nerve fibers and vessels to the front. It should be understood, therefore, that the rods and cones are not really modifications of the nerve tissue, but of the membrane through which this is interspersed. This is best shown at what is known as the yellow spot (macula lutea, a circular depression of a yellowish color about the middle of the retina), near which is the point of entrance for the optic nerve, whence it spreads its fibers into the retina proper. At this point of entrance the nerve fibers predominate, and the rods and cones are absent, while at the yellow spot the cones are abundant and close-set, while the rods are scanty, and found only toward its margin. The exact use to which these rods and cones are applied is not definitely known further than that it is their function to transform the waves of light into the impression which we know as sight. This sensation takes place in the brain, for a hard blow on the back of the head will make us see stars, although it be broad daylight.

Similarly, irritation or galvanization of the optic nerve will produce the sensation of light even though the eye and the retina are destroyed. Light, says Huxley, falling on the optic nerve does not excite it; "the fibers of the optic nerve in themselves are as blind as any other part of the body." But just as the delicate filaments of the ear and the fibers of Corti are contrivances for converting the vibration of the fluids of the ear, so the vibration of the fluids of the eye may be similarly converted into the sensation of light and color. "There is," says Professor Barret, "a striking analogy between music and color; the rate of vibration in sound gave rise to the gamut, and in colors the rate of vibration in like manner gave rise to the notes forming the spectrum. The colors of the spectrum showed a sequence analogous to the sequence of pitch in the gamut. Newton thought that there might "be a correspondence between the length of the spectrum colors and the vibrations of musical sounds, but the true relationship was between the vibrating pitch of color and the vibrating pitch of sound. The extreme limits of the spectrum embraced an octave in music. Calling red 100, the proportionate vibration of orange was 89, that of yellow 81, that of green 75, that of blue 69, that of indigo 64, that of violet 60, that of ultra-violet 53, and an obscure or extreme violet 50. The vibration of C in music corresponded to that of red in color, and taking C as 100, the vibration of D was 89, that of E 80, that of F 74, that of G 67, that of A 60, that of B 53, and that of C 50. The vibration of unison, rendered visible, produced on a screen the figure of a circle, that of an octave formed a figure resembling 8, and combinations of figure formed by the visible reflection of intervals of a fourth, a sixth, etc., were proportionately complicated."

The sensibility of the different portions of the retina to color and light varies very greatly. At the entrance of the optic nerve the retina is absolutely blind, but elsewhere light and color impressions have a duration of their own. About an eighth of a second is required for the first of these, so that impressions of light which follow each other more rapidly

than an eighth of a second are practically continuous. A striking illustration of this may sometimes be seen in riding rapidly past a board fence in which there are numerous perpendicular cracks. Through each of these the eye gets but a passing glimpse, but these succeed each other so rapidly that to all appearance the fence is abolished, and we can see almost as plainly what is beyond it as if no fence were there. The excitability of the retina is, however, soon exhausted, for continued gazing at a bright light quickly exhausts the susceptibility of that part of the retina upon which its rays have fallen. Turning now from the bright light and looking toward a light surface you find a dark spot corresponding to the bright one just looked upon. If the bright light be of one color the retina becomes exhausted for that tint only, but may recognize other colors. Each color has what is known as its complementary color, and these are those which will be seen in the image produced by this temporary blindness of the retina; for instance, if a red cross be made upon a sheet of white paper and steadily gazed upon for a while with one eye, and then this turned to look upon a page of perfectly white paper there will be apparently seen upon this a green cross of exactly the same size and shape as the red one just looked upon, although somewhat less distinct in outline.

Boll, a recent observer, thinks that the ability of the retina to recognize hues is due to a peculiar red color, which is constantly being destroyed by the influence of light and is as constantly being regenerated by the ordinary processes of nutrition. The "vision red" or "erythopsin," as its discoverer names it, attains its maximum after a night's rest and sleep, or when an animal has been kept for some hours in darkness; it is soluble in solutions of the biliary acids and in glycerine, and probably plays a part in the production of the red reflection from the fundus of the eye seen by the opthalmoscope. Possibly the loss of erythopsin constitutes the color-blindness whose more common form is that caused by the absence of perception of one of the three fundamental colors. These are mentioned in the order of their comparative frequency:

namely, where the elementary sensation corresponding to red is wanting; next, the absence or imperfect perception of green; and third, of blue or violet. It will be noticed as a remarkable fact that the first two colors are those now used to make up the entire code of railway signals, and that this defect for red occurs more frequently than for any other color. This is an item of the greatest importance in railway and vessel management, since red is almost always used for the danger signal. To add still further to the deceptive and dangerous character of these defects, there are quite a number of persons who are unable to distinguish between the primary colors at night, while their perception or sensation of color by daylight is apparently perfect. Again, there is another defect, which is an inability to distinguish between or to recognize the primary colors at certain distances, varying more or less in individuals. This was found to be the most difficult of all defects to detect by the ordinary tests for color-blindness.

On account of the importance of color blindness, in relation to the danger signals on railroads and steamboats, it is usual to test all those wishing for employment by means of the matching various colored worsteds. Samples of various colors are given to the one on trial, which he endeavors to match. Examinations show, among men at least, one out of every fifty defective, and many to a degree that unfits them for any service requiring accuracy in the perception of colors. The defect is often congenital, but is also known to be caused by alcohol or tobacco, and by some forms of mental disease.

Besides color-blindness the eye is subject to various defects inherited and acquired, such as squint, myopia, presbyopia. Squint or cross eyes are where their axes do not correspond, so that vision is practiced with one eye instead of two. Squinting is often a bad habit, which, as soon as observed, should be obviated by using the eyes one at a time, and looking with each in a direction opposite to that toward which it inclines, or using the affected eye a little from time to time

with the finger extended over the nose as an additional septum to increase its height.

Myopia, or near-sightedness, is most frequently found in students and school-children, and is caused by poor light, poor printing, either in regard to the size of the type or color of the paper; improper ventilation; faulty positions while studying; whatever tends to produce any congestion about the head, and lowering the vitality from any cause whatever.

Dr. Andrews says on this subject: "In early life the tissues are soft. Some eyes are believed to have a more yielding or plastic tissue than others. The extensible, sclerotic coat becomes stretched. The yielding occurs most at the rear of the eye-ball, which thus becomes elongated. So the retina is moved behind the best locality for focalizing. No doubt this exists sometimes as an inheritance or an anatomical defect. But far oftener it is a yielding caused by the improper use of the eye.

"The act of accommodation of the eye is, by nature, one of slight but of healthy tension. But if constantly overdrawn, or if the tissue of the eye is flabby or not sufficiently resistant, the form is changed so as to become a serious defect. The child that uses the eye too early or too much in study, or with wrong type or books, or when the general health is not good, or too soon after recovery from sickness, or in overheated or foul air, or in too great a glare, or with deficiency of light, is too likely to give a training to the eye which secures for it more or less imperfection of vision."

Some practical hints for the care of the eyes may be found at the close of the present chapter, in which, if space allowed, it would be interesting to attempt to solve the question whether sight, or perception of the form of external objects, is possible in any other way than by the eyes. It would open a long and difficult theme for discussion, but in the midst of much willful deception on the part of clairvoyants and mind-readers it seems clearly proven that somnambulists, or sleep-walkers, go wherever they please

without hesitation, read and write, and give ample evidence of a power of perception independent of the usual organs of vision. Persons subject to attacks of catalepsy frequently show the same peculiarity. M. Despine, late inspector of the mineral waters of Aix, in Savoy, mentions the following among many other cases: "Not only could our patient hear by means of the palm of her hand, but we have seen her read without the assistance of the eyes, merely with the tips of the fingers, which she passed rapidly over the page that she wished to read. At other times we have seen her select from a parcel of more than thirty letters the one which she was required to pick out; also, write several letters, and correct on reading them over again, always with her finger ends, the mistakes she had made; copy one letter, word for word, reading it with her left elbow, while she wrote with her right hand. During these proceedings a thick pasteboard completely intercepted any visual ray that might have reached her eyes. The same phenomenon was manifested at the soles of her feet, on the epigastrium, and other parts of the body, where a sensation of pain was produced by the mere touch." Persons who have become blind have also been known to acquire the same power, for example: Harriet Martineau tells of an old lady who had been blind from her birth, and yet saw in her sleep, and in her waking state described, the color of the clothing of individuals correctly. In these cases, no doubt, perception is, as usual, in the brain; but either all the nerves of the surface have the power of conveying the impressions of light to that organ, or some special parts of the body, as the ends of the fingers, the occiput, or the epigastrium, assume the office of the eyes.

These phenomena might be explained by the heightened muscular sense spoken of previously. In their last analysis all sense perceptions are some form of touch. But the eye is also a well-constructed optical instrument, for without taking further time to describe minutely all the parts of the eye—and it is most daintily put together—please to remember that it is essentially a water camera. The sclerotic is the

box, the cornea and crystalline lens are the lenses, and the retina the plate on which the picture falls, upside down, too, just as you have noticed it at the photographers; but we have been so used to seeing things upside down that when we do see them right side up they look just the other way. This and some other minor defects so provoked a crabbed pedantic German optician, that he declared lately that if the eye was brought to him as an optical instrument he would throw it away on account of its many faults. If this is so, it is a great pity that he was not consulted before our eyes were made; for unfortunately a poor eye cannot be made as good as new. Moreover, good care must be taken of the "blue seas," "dark pools," "lode stars," or whatever else the poets may call them; these willing servants must not be overtaxed. Nature gives you fair warning when you are doing this, and just as soon as the eyes begin to feel tired give them rest, even if you are only two pages distant from the blissful marriage of the heroine. Eyes that look as if they were trimmed with red tape would take away half the charms of a Venus, to say nothing of the unlovely temper that it produces to have your eyes feel as if they were full of sticks. For all of which reasons take good care of these photographic galleries of yours, and above all never admit there a picture which you would be unwilling to see again. It may color the retina but for the fraction of a second, and then is gone, as we think forever; but not so. Its negative has only been laid away in the brain, and we know not at what day or what hour memory's magical chemicals may bring it back in all its sickening realities. Finally, heed Dr. Lincoln's directions for the use of the eyes, which are so practical and useful that we copy them entire from Dr. Hunt's *Hygiene:*

"When writing, reading, drawing, sewing, always take care that, (*a*) the room is comfortably cool, and the feet warm; (*b*) there is nothing tight about the neck; (*c*) there is plenty of light, without dazzling the eyes; (*d*) the sun does not shine directly upon the object you are at work upon, or upon

objects in front of you; (*e*) the light does not come from in front; it is best when it comes over the left shoulder; (*f*) the head is not bent very much over the work; (*g*) the page is nearly perpendicular to the line of sight; that is, that the line of the eye is nearly opposite the middle of the page, for an object held slanting is not seen so clearly; (*h*) that the page or other object is not less than fifteen inches from the eye; (*i*) in any case where the eyes have any defect, give up needlework, drawing of fine maps, and all such work, except for very short tasks in the moining. (*j*) In addition, never study or write before breakfast by lamplight; (*k*) do not lie down when reading; (*l*) if your eyes are aching from fire-light, from looking at the snow, from overwork, or other causes, a pair of colored glasses may be advised to be used for a while; (*m*) never play tricks with the eyes, as squinting or rolling them. (*n*) The eyes are often troublesome when the stomach is out of order. (*o*) Avoid reading or sewing by twilight, or when debilitated by recent illness, especially fever. (*p*) It is indispensable in all forms of labor requiring the exercise of vision on minute objects that the worker should rise from his task now and then, take a few deep inspirations with closed mouth; stretch the frame out into the most erect posture, throw the arms backward and forward, and if possible step to a window, or open air, if only for a minute.

To test for color-blindness, obtain a set of test worsteds, which should be spread upon a white cloth. First lay the green skein a little to one side, and tell the subject to lay alongside of the test skein all the skeins containing a shade of that color in any degree. Avoid naming "green" to him. If he throws out only shades of green or light blues his color sense is normal (C.S.N.) and the test is completed. But if in addition he throws out any shade of gray, or light yellow, salmon, or pink, he is color-blind. If he hesitates, as if in doubt about them, but yet does not throw them out, he probably has "feeble color sense" (C.S.F).

CHAPTER VII.

TELEGRAPHS AND PHONES.

WHAT is a nerve? If you ever watched a dentist draw one out you will probably remember that when it came it looked like nothing as much as a little snip of wet, white cotton thread. Very likely you were provoked that such a contemptible little thing should have given you so much pain, but if you put this thready bit of nerve beneath a microscope you will find it far different from any thread that ever came from the reels of a Clark or Coates. One of their fibers would look beneath such a glass like a huge, knotty hawser; but this nerve is shut up in a smooth, shining sheath. Break into this and we find the true nerve fibers, which consist of tubes made of a white substance (of Purkinje), and the axis cylinder, or gray substance (of Schwann). This pearly gray substance is the really essential part of the nerve, the wire in this telegraph system, and all else are but accessories and packing, something like the gutta percha wrapped around the wires in a submarine cable. Hence we find that wherever we are to receive impressions, this gray substance of Purkinje is always on hand to receive and transmit these messages, pleasurable or otherwise.

In the nerve we have been considering we have all the kinds of nervous matter that are known to us; namely, the gray, white, and their various sheaths. But these substances may be arranged in very different ways. We may have a simple nerve fiber, or we may have a perfect whorl and maze of these simple nerves, looking so much like a tangled spool of thread that they have been called a *plexus*, from *plexto*, to weave.

Again, we have nervous masses which are called ganglia,

knots. And such they are, for they are really gordian knots of the gray substance, which in these ganglia takes the form of brambly cells, each containing in its center a dot of our old friend, germinal matter.

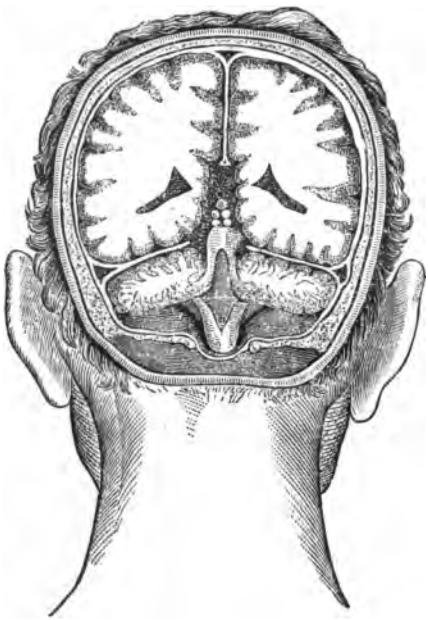
These ganglia, or nerve knots, appear to be in fact small brains, placed where most needed, and doing their peculiar work without troubling the greater brain, or encephalon; thus, for instance, there are fifteen or twenty of these ganglia scattered through the heart, and it is to these that the heart carries its wants, only in rare and dangerous cases appealing to the higher court of the brain proper for assistance.

Sympathetic ganglion cell from man.—*Klein.*

These ganglia, plexi, and simple nerve fibers are all that we find in the sympathetic nervous system. (See cut, page 93.) Nerves, like the muscles, are of two kinds; namely, those which act without our knowledge, and those which give us fair warning of their troubles and trials. The involuntary nerves have been named the sympathetic, the others the cerebro-spinal system. It is the sympathetic system by which, when we sleep as well as when we are awake, we live and have our being, for it regulates the work of the heart and lungs and all the functions of mere animal life.

The lowest forms of animals have only this sympathetic nervous system, the very lowest owning nothing but a single ganglion with two or more nerves attached. Rising in the scale, we next find animals with two or more of these nerve knots about the mouth, or arranged in pairs like the ganglia down the back of a caterpillar.

But we have no right to despise those animals which have only nerve-knots for brains; for to tell the truth we are all made after the same plan. There was a time when all this wonderful nervous system of ours consisted of only two white cords wrapped in a bit of cartilage. After a little there appeared on these little cords five tiny swellings, looking like beads on a string, and if you should look into the



Cross-section of the skull and brain, made just behind the ears, showing the ventricles, corpus callosum, cerebrum, and the longitudinal and transverse sinuses.—Rosers' *Vademecum.*

brains of all the higher animals you would find the same five swellings, somewhat enlarged, to be sure, and now we call them ganglia; but these same five ganglia can be detected in almost every cranium. In the lowest fishes they lie open, like eggs in the nest of a bird, but in our brains they are sheltered beneath an arch which we call the hemisphere of the brain. (See cut above, which also shows that the larger

brain, like the rest of us, is made of two halves, so joined together by a strong band that they form a sort of flattened sphere, rough outside and smooth inside.)

The heads into which I have had the privilege of looking I have found well packed with a grayish pulp which goes under the name of brains. You have all heard this compared to blanc-mange, but to me it always looks as if the blanc-mange had been allowed to get very dusty, and, to tell the truth, they remind one by their color and appearance of hasty pudding or well boiled Indian meal.

This grayish tint is due to the same gray substance that we found in the nerve fiber. There it was inside, but here mainly on the outside (excepting the ganglia). Hence we might consider the brain as made up of a vast number of little star-like bodies (nerve-cells) held together by millions of pellucid threads, the same which, wrapped together in bundles, we call nerves, and when we cut down into this mass of connecting threads they look as white and creamy as the nerves themselves. It is nerve matter, and, as we presently shall see, its office is the same as nerves every-where else; namely, to carry messages.

Few of you, I presume, will ever peep at the brain of a human being; but any of you can get a very fair idea of its shape from the next English walnut which you crack at dessert. This resemblance was observed at least as early as the days of Cowley, who found similarity not only in shape, but also in its coverings to those of the brain:

> " Membranes soft as silk her kernel bind,
> Whereof the innermost is of the tenderest kind,
> Like those which on the brain of man we find,
> And which are in a seam-joined shell confined."

And just here we must spare a moment for the three membranes which line our "seam-joined" brain-shell. These the anatomists have named the *dura mater*, the arachnoid, and the *pia mater;* or, the harsh mother, the spider's web, and the loving mother. Very poetical, to be sure, but the medical stu-

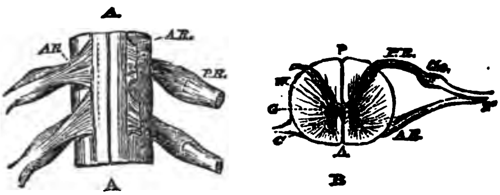
dent gave us a better idea of their uses when he called them respectively the brain's coat, shirt, and flannel; and truly the *dura mater* coat is a good fit of the best material, for it is so tough, and lines the cranium so closely, that you can crack a skull with a hammer without tearing the *dura mater*. The spider's web shirt, as its name implies, is very delicate, and scarcely more than a smooth surface over which the tough *dura mater* can glide without injuring the blood-vessels in the pia mater. The latter is not so much a membrane as a perfect net-work of capillaries, into which larger blood-vessels divide and subdivide, lest by their pulsation they should disarrange the pulpy structure of the brain. And now, though these membranes have been spoken of as the brain's clothing, please remember that they are found not only around the brain, but the same three, with only slight modifications, are also stretched over the after-brain and clear down the spinal cord; for the spinal cord and its fluids are held in a triple sack like the brain.

And now just a word or two about that little after-brain, or cerebellum, which is hung on the back of the cerebrum, like the little "cannon-ball water-falls" with which the rage of false hair began. The cerebellum is hollow and furrowed and puckered, but so unlike the rest of the brain that it seems to have been made on a different plan. It is so curiously mixed gray and white nerve matter, that a cross section of it would make you think of marble-cake. So it appears as if the cerebellum was made up of three crumpled bags. From this bag issue four legs; three of these unite to make, as we shall presently see, the most vital part of the body, the medulla. The whole spinal cord might be considered as a tail to the cerebellum, and is made up of a pile of the ganglia, or nerve knots, from whose sides issue thirty-one pairs of nerves, whose functions will be described later.

The different parts of the nervous system have very different duties. Unfortunately for physiology, most men object to have their brains experimented upon; but dumb animals have no rights that French physiologists think them-

selves bound to respect; so they have thrust red-hot needles through the various ganglia of pigeons' brains and noticed what faculties were impaired by so doing. From these experiments, and the various injuries to the human brain of which we have reliable accounts, it seems very probable that its various faculties might be mapped like a geography into regions of

a—Conscious thought.
b—Smell.
c—Conscious sensation.
d—Voluntary motion.
e—Sight.
f—Forwarding house.
g—Vital point.



THE SPINAL CORD.

A. A front view of a portion of the cord. On the right side the anterior roots, *A. R.*, are entire; on the left side they are cut, to show the posterior roots, *P.R.* B. A transverse section of the cord. *A*, the anterior fissure; *P*, the posterior fissure; *G*, the central canal; *C*, the gray matter, *W*, the white matter; *A.R.*, the anterior root, *P. R.*, the posterior root, *Gn*, the ganglion, and *T*, the trunk, of a spinal nerve.

We might, too, consider the spinal cord as thirty-one little brains piled atop of one another, each of which has its double pair of nerves. Generally these spinal ganglia do their work without troubling the greater brain. For instance, we are cramped, and move to make ourselves easier without thinking to will any thing about it. And how do we do this? Something in this way: I imagine a message comes creeping up the "P.R." root of a spinal ganglion, saying such and such muscles are tired and need a change. These ganglia are something like a police justice in that the minor grievances

of the body are carried to them and, if possible, disposed of without appealing to the brain. If, therefore, this "P.R." ganglia finds that the case comes within its jurisdiction it sends its command back down the corresponding motor nerve, and the matter is speedly ended. But suppose this "P.R." ganglion has not been sufficient for the case; we may have cut our finger, and the smart is not appeased by simply pulling the finger away from the knife-blade. The "P.R." ganglion has done all it could, and so it sends word up to the optic thalamus (see cut) by means of myriads of little sensory telegraph wires, which cross over almost as soon as they enter the cord, for the bureau for right-hand pains, etc., is on the left side of the brain, and *vice versa.* And now you have the information at sensation headquarters, and what are you going to do about it? That depends upon circumstances. It might remain there simply as a sensational pain and that be all about it. But unless you are deeply engrossed in something else, or very stupid, the word is telegraphed up to the supreme court in the region of conscious thought, which ought to give a verdict according to its best knowledge and previous experience—or too often from caprice. For instance, it might decide that you need not do any thing about it, and there the matter ends; but more likely it decides that the wisest thing for you to do is to put that finger into your mouth, or put a light bandage around the limb, or this, that, or the other thing; but whatever is resolved to be done is immediately telegraphed down to the bureau of motion—usually a whole batch of commands, such as in the first case, where we might suppose them to be: stick up your finger, elevate your wrist and arm, open your mouth, etc. Now this whole squad of commands is hurried down to where the work is sorted out, and particular orders are sent to each muscle, whose aid will be needed in this intricate work; for even a little thing, as moving one's finger, requires more servants than were necessary to move the king of Spain back from the fire. All this the cerebellum attends to, and sends each message of these crossways down

the neck until they all come out of their appropriate motor nerves, so exactly in the nick of time that one might think thrusting your finger into your mouth had been your one great work since you were born.

If you ask what these nerve messages are I must tell you frankly that I don't know. Many physiologists think them a subtle form of electricity. Possibly it may be, but I want to say just here that though the soul may use electricity to send its messages, yet the electricity is no more a soul than the message sent along the telegraph wires is the man who sends it. The materialist would have us believe, because he finds heat and electricity in the brain, that there is no soul besides these. As well believe that the click of the key and the fuming of the battery could send intelligent messages across the Atlantic without an operator. We have been describing only our marvelous telegraphic apparatus, which anticipated Professor Morse by some 6,000 years; but its operator hath no man seen at any time, for spirit must ever elude the physiologist's grasp.

So we would do better to quit grasping after it, for at best we should only result in failure. But we may spend a few moments profitably asking how these messages are sent "and what will follow on their using." We say as quick as thought, but Professor Helmholtz has discovered that we can think no faster than eighty feet a second, according to the direction in which we would send it—by which I mean that an order or pain cannot travel up and down a nerve faster than the previous mentioned rates; whereupon some English mathematician, who evidently was trying to keep Satan at bay, sat down and figured up that we could not possibly entertain during a life-time more than 3,155,160,000 distinct ideas. Nothing like being exact. But unfortunately it does not follow that we all have that number of distinct ideas; for we need training to think, as much as we once did to walk. It is a trite saying that we are bundles of habits, and in nothing is this more true than in our ways of thinking. We are very apt to think in ruts, especially as we grow

older. "For custom hath made it a property of easiness," and do we not all like to take our ease in our own inn? Take "slang," for instance; slang is only mental laziness, in using some senseless phrase in such a way that you force your listener to guess your meaning, providing what you say has any. Just now it may sound very piquant and witty, but that unlucky phrase will thrust its head into society at some time when it will make you heartily ashamed of yourself. And so of the thousand and one uncouth actions and tricks into which we fall as easily as sliding down hill.

So let us go back to our telegraphic apparatus and ask what are its charges for sending messages. Why, nothing, you say. Are you so sure of that? I know that nature posts up no tariff of so much for the first ten words, but nature's charges are no less certain. She is a very Shylock in the bonds that she makes us give for the use of these nerves, and gets the pound of flesh. Ask your friend who suffers from the neuralgia, etc., whether nature's knives are not keener than any made of steel. Just here I want to say that for those poor mortals whose bonds went forfeit by their parents before they were born we ought to have only the kindliest pity; for they live in a prison-house of torture of which one in good health can have but the faintest idea. Why these fearful penalties have been set over against our most exquisite pleasures is more than I can say; but "the law allows it and the court awards it," so there is no use of our murmuring, especially as there is rarely necessity that our bonds should go forfeit. Each thought and sensation requires a certain expenditure of nerve influence, electricity, psychic force—I care not what you call it, as long as we understand that every thought takes something from our nervous supply in the same way that every message requires electricity; and just as the battery needs provision for a fresh supply so must our nervous system have its supplies. Ample provision has been made for this. Sleep is nerve food *par excellence*, and as long as we have this we can laugh old Shylock nature to scorn; for regular

natural sleep is the solid coin with which we ought daily to meet his bond. How much does he demand daily? That depends upon the person; for no inflexible law can be laid down for every one. The old saying was, six hours for a man, seven for a woman, eight for a child, and nine for a fool; and if that be true I am afraid that there are more children and fools than men and women in America. We live too fast, and in consequence are the most restless and irritable people in the world; which simply means that the Shylock nature is letting us gradually overdraw our account, and some day, when we least expect it, he will have his forfeit, though it leaves us nervous wrecks or raving maniacs.

There is an Italian who has invented what he calls a "nerve-tuner," by which he promises when we are all unstrung—on edge, as we call it—with a few twists to put our nerves, like the strings of a piano, back into concert pitch and keep them there. Thrice blessed Italian, come to America, and if what thou sayest be true we will greet thee as never was man greeted before! But in the meantime we may say with Sancho Panza, "Blessed is the man that invented sleep!" Here is no opportunity to quote the many beautiful tributes to sleep, or even to discuss what sleep is, but only to say bluntly that this matter of sleep settles largely what kind of men and women we are. There is a pleasurable excitement in the whirl of fashionable life, but does it pay? For each hour thus spent we have to pay its full price, and nature's laws cannot be defrauded the twentieth part of one poor scruple. No form of battery can be used continuously without exhaustion.

Sleep is nature's method of recharging aright these subtle batteries of ours, without which we cannot be sound either in mind, body, or estate; therefore, count it among your greatest blessings if, like Sam Jones, you can go to bed and sleep. "Sleek-headed men, and such as sleep o' nights," may be of little value as conspirators, but they are happier men and better citizens than those who lie awake o' nights to plot and plan. In fact, it is a general and safe rule that

when business crowds itself into your sleeping hours your business is pushing you, and not you your business. Beware, for the time is not far off when you and your business must part company, probably both of you crippled by your undue zeal. The first signal of danger being done to these exquisite nerve-batteries is wakefulness. You can't sleep as you used to, or you sleep restlessly, and dream perpetually of your daily vocation. Look out, or the undue tension may ruin irretrievably the delicate mechanism of your brain. "O, nonsense," you say. "I live on excitement, and don't need as much sleep as formerly." Nature never makes any mistake. As well might you disregard the warning bell of an approaching locomotive as this symptom of wakefulness without apparent cause. You may in either case escape with your life, if you continue on your way without heeding the warning bell, but the probabilities are that you will be permanently crippled from the unequal contest. America, more than any other civilized country, is full of men, and women especially, who drag out a wretched existence simply because they have disregarded these warnings of an overtaxed nervous system, and have kept on their way until they were tossed aside by the engine of wealth, fashion, or ambition, and left crippled wrecks for the rest of their lives. "O, but every body does so, and I must somehow, or I shall be talked about and pitied." Then be talked about and pitied for a while; continually so, if necessary; but, for the love of your own bodies and souls, don't commit suicide, for it is nothing less. Perhaps if only yourselves and your families were to be considered your suicide would be preferable, for this nervous exhaustion produces an irritability and waspishness that makes your coming more dreaded than the gout. You are harsh, crabbed, unreasonable, suspicious, until you hate yourself, and the world looks hopefully on toward your death. And all this solely because you will have your own way, and hurt yourself in spite of all that can safely be done to prevent you.

Does it pay? No, you say; I know it does not, and I have

prayed for grace to carry me through this time of trial. My dear madam, will you allow me kindly to say that you need rest fully as much as sanctification? Perhaps I would better say you need rest and sanctification, for your burden is largely self-imposed; so don't carry it any longer. "But," says a busy man, "I can't lay my burdens down. I know they are self imposed, but just now my affairs are in such a condition that it is the height of folly to neglect them." My friend, whoever you are—preacher, teacher, doctor, over-anxious mother—if you are getting nervous, irritable, wakeful, it is the height of folly to keep at what you are at present doing. Stop while you can, for before long stopping will be useless. Instead of stopping you will be stopped, or "lag superfluous on the stage."

Another manifestation of nerve-tire is neuralgia, usually, too, an affection of the better and more finely organized half of humanity. Woman's greater endurance is purchased at the expense of a greater wear and tear of her nervous tissue. A man will lie down when overworked and dispirited, and groan off his nervous depression until he comes to a better frame of mind and body, while a woman under the same circumstances will literally go through fire and water to finish what she is doing, whether or not it is worth doing at all, and then go into nervous bankruptcy. Her nerves, so long kept at undue tension, now fairly shriek in agony, and we say she is a martyr to neuralgia. And she is that, but in the same way that a man is a victim to bankruptcy after he has recklessly speculated beyond his means. Neuralgia is the torture of paying overdrafts on our nervous system without resources to fall back upon. In such a plight there is no other man to do the walking all night, and so you needs must do it, while Shylock nature is cutting off her pounds of pain for the ducats you so lavishly squandered. Does it pay? None of us who have ever been there would say so while in the torture, but too many of us soon forget this sharp lesson, and go on discounting and rediscounting our nervous paper until we come to that absolute nerve-penury or pauperism to

which the doctors give the name of *neurasthenia.* I do not mean to say that every case of neuralgia is due to overdrafts on the nervous system, but in nine times out of ten it can only be cured by living within the honest limits of our nervous system. I know that is often annoying and painful to one with large ambitions and small resources, but so it is elsewhere and every-where. Better the narrower and often humiliating limits of a well-preserved nervous system than the pinching poverty of years of neurasthenia.

Neurasthenia—literally, weakness of the nerves—is a fashionable complaint in these latter days, but it truly designates a pitiable condition, not to be laughed at or despised by those more fortunate, any more than poverty elsewhere. If you are so broad-waisted and strong-armed that you do not know you have any nerves, be thankful for it; but know, nevertheless, that our modern civilization has given us as one of its products the neurasthenic woman, whose every nerve lies quivering on the brink of an explosion of pain. Strong coffee, poor ventilation, improper food, fashionable clothing, the hot-air furnace, the sewing-machine, the three flights of stairs, and, more than all these, the worry and fret and ambitions of modern life, have stolen away the bodies and health of our American women.

I have frequently walked our city streets looking through the crowds almost in vain for a thoroughly healthy-looking American girl. Bright faces, stylish dresses, graceful figures, intelligent and cultured countenances can be found on every hand, but joined to such bodies that it makes your heart ache for their probable futures. These girlish forms will make the nervous wrecks of the next twenty years, and may the coming doctor know how to treat them better than those at present on the stage! Said an exasperated physician once in my hearing: "Great heavens, madam, you bring me ninety pounds of nervous wreck, and a handful of false teeth and hair, and ask me to make a whole woman out of that in two weeks. It can't be done, madam, it can't be done." Alas, it can't be done, it can't be done; and if recovery

comes at all it must come as the result of many months of weary watching and patient care.

Better fewer accomplishments, better less company, better less excitement, better fewer books, papers—yes, better less almost any thing—than the modern city, bloodless, libel on God's idea of womanhood. The Creator made every thing good, and if we are not such as he would have us it is because we prefer our way to his; and our ways not being as wise as his we necessarily fall into trouble. Even then the penalties are the lightest and best that eternal wisdom can devise to correct mistakes and stubbornness; but we will and we wont, like stubborn children, and then, in the intervals of the pain sent to prevent further pain, we groan out that we are fearfully and wonderfully made.

So we are; and there is no more exquisite instance of this than this same nervous system, which is to us the source of all our pleasure and pain, chiefly given to prevent us hurting ourselves; for, did you ever stop to think what great care has been taken to guard us from all possible harm? No safety deposit vault ever had half so much pains taken to guard its treasures as have been lavished upon the house in which we live. Thousands of dollars are freely spent to connect these safety vaults with burglar alarms and proper protection, but no one has ever dreamed of encasing them in such a net-work of protection as is found in every square inch of our bodies. Our burglar alarms are our nerves, and so complete is the entwinement of these nervous fibers about our bodies that if there were any way in which the rest of our bodies could be dissolved away from them, leaving the nerves intact, these would give us a complete outline of the whole body almost as perfect as that of the areolar tissue. (See page 22.) So intricate is this interlacing of these tiny white nerve-fibers over the surface of the body that you cannot thrust in the point of the finest cambric needle without touching a nerve; for it is these alone that make us feel pain. Blood, bone and muscles give us no sensations when they are cut, for a paralyzed limb may even be amputated

without feeling, because its nerves no longer respond to their usual stimuli.

What, then, is this nervous system, which, like most of the other good things we enjoy in this world, is capable of making us exquisitely happy or wretchedly miserable? It is made up, as has already been said, of at least three parts; namely, (1) the general office (brain), (2) automatic trunk-lines (spinal cord), and (3) special receiving offices, distributed over the whole body, so that you cannot touch one of them anywhere, even with a pin, without having word instantly sent to the general office as to where the trouble is.

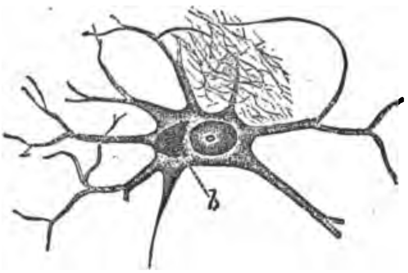
This general office we call the *brain*. As already said, when taken from the body it looks very like a bowl full of ill-cooked mush or blanc-mange. And yet on the way in which we use those two handfuls of grayish matter hang our destinies for all time and eternity. It would take a large library to hold the books that have already been written upon the various parts and functions of a human brain, and we are very far yet from knowing all that we would like to in the matter. Suffice it now to say that we have good reasons for believing that the different parts of our brains do different parts of our head-work. One part tells us of forms and colors, another of distances, another of words and thoughts, and so on, until a map of the brain under the present system is almost a short course on the mental and moral faculties of man. It is, in fact, an unsurpassable telephone board for all the wants, desires, and pleasures of man, such as nothing but infinite wisdom could have constructed.

Hardly less wonderful are the automatic trunk-lines, or spinal cord and nerves, as they are usually called. These are really, as you see, a prolongation of the brain, located in the backbone to protect it from injury. (See cut, page 58.) In regard to their functions, imagine, if you can, a telegraph line whose wires are capable of doing their work without direction, and you have in brief a very good idea of the work done by the spinal or reflex nerves. If you look at them a little more closely, you will find that, like the brain, they are divided

into two equal parts, longitudinally, one to serve each half of the body, and that these halves, on account of their soft, gelatinous composition, are wrapped in no less than three tough enveloping membranes, and then the whole is inclosed in a bony case. Like the brain, they are made up of white and gray matter, the latter inside of the white and forming there on cross section a sort of rude letter H. From the extremities of these H's sixty-two spinal nerves are given off and pass out to perform their duties through as many notches, or holes, in the backbone. These nerves form thirty-one pairs, and soon unite into a common trunk by means of a ganglion.

Now, ganglion is a Greek word for a knot, and is used to denote curious little knots or swellings found every now and then along the course of nerves, especially where they branch or unite with other nerves. The use of these ganglia was for a long time unknown, but latterly it has been well proven that they act the part of subsidiary brains, and are capable of doing automatically less important work. They all have direct or indirect connection with the brain proper, and if necessary can communicate with it, but are capable of running very much of our body without any interference with it from the brain proper. For instance, we start off to walk. We are conscious of willing that our leg machinery should propel us forward, but once having started it we leave the rest of the work to the ganglionic and spinal nervous system, without giving any thought to it until it is time for us to will to go in some other direction; then we telegraph to the ganglia to carry us in that way, or stop, as the case may be, like the conductor and the fireman on a train. These ganglia, then, regulate automatically the pressure of our feet and the proper contraction and relaxation of all the muscles necessary for locomotion without our giving any conscious thought to it. This they do by automatically regulating and controlling the proper nerve supply—or co-ordination, as we call it. Why, for instance, does a babe put his spoon as often into his ear as into his mouth? Because his ganglia have not yet learned to co-ordinate his muscles and to force them into work in harmony. And

so it would be with us in every action requiring more than a single muscle, if it were not for these little insignificant knots of gray nervous matter. Alcohol takes away their power of co-ordination, and hence we see drunken men "reel to and fro and be at their wits' end" to know which way to lean, or how to sit down without holding on; and the most sober man in the world would be in like plight if it were not for these ganglia, which act very much like the relays, I believe they call them, on a telegraphic circuit, which do so much of the work of transmission without requiring a conscious operator in their stead.

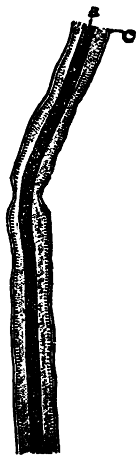


Isolated ganglion cell from the anterior horn of the human cord.—*Klein.*

So it is with our ganglia. If it were not for them we should be tired to death merely trying to remember to keep alive. How is it that we never forget to breathe? We certainly do not think to do so every time. Why, these ganglia and respiratory centers take the matter in hand, and we have never to give it a second thought until our lungs get out of repair, or are overtasked with an unusual amount of work. Whether we are sleeping or waking, busy or idle, happy or broken-hearted, these patient, uncomplaining servants work on and on and on for us, giving us leisure for improvement and the pursuit of happiness. The work of certain ganglia, as the respiratory centers, we can increase or diminish somewhat at will, but we cannot entirely stop them at our volition, for we cannot hold our breath, voluntarily, until we choke. And over other of these automatic centers we have no control at all, as, for instance, those which regulate the heart's actions, which are entirely beyond our willing. The brain's function is to receive the messages passed into it by the nerves, and to decide from these impressions what is best to be done under the circumstances. This is what we call psychic force or power,

and its seat is located in the anterior hemispheres of the brain, especially in the gray matter of the cerebrum, as this part is called. Just behind and below the cerebrum, as may be seen on page 188, is the cerebellum, or little brain, and its prolongation, the medulla and spinal cord. In this cerebellum you see a curious leaf-like arrangement, to which the older anatomists gave the name of the *arbor vitæ*, or the tree of life; and it is well named, for in it are the ganglia, or centers, which regulate our breathing, heart's beating, and all the functions which are necessary to carry on our lives.

These are automatic, as has already been said, and hence, as we sometimes see, a man may live for years after all his powers of thinking and perception are gone; for these automatic centers work without his will or wish. Other of these ganglia act reflexly, or by irritation elsewhere than where the results are produced; for example, sneezing, which is a spasmodic expulsion of air from the lungs, and is produced not by irritation in the lungs, where the spasm takes place, but in the nose, whence the irritation is transmitted to the ganglia, whose duty it is to forcibly drive the air out of our lungs when required, whether we like it or not; for we can no more help sneezing than breathing. How does this impulse or irritation pass from the nose to these centers?



The axis, (*a*) a pale, faintly fibrillated band or cylinder—the gray substance of Purkinje. This has a very delicate transparent sheath, and external to this we find the white substance of Schwann (*c*) analogous to the white substance of the brain.

Their microscopic appearance has already been described; but we would again call to mind the axis-cylinder, the central tiny white fiber, and around this (*a. c.*) we find an oily grayish substance that in life is probably fluid, but after death becomes gelatinous and acts like the rubber that is melted and poured around the central core of our great submarine cables. Outside of the rubber in these cables we have an outer sheathing, and we find a similar arrangement

in our nervous system; for each nerve is covered over with a sheath, and each bundle of nerves is again covered, exactly as we find the cables of wires covered with paraffine for the use of the telegraph and telephone companies. The purpose of the paraffine or rubber in these is to prevent leakage of the electricity, as these packings and sheathings are non-conductors of electricity. The same is true of the nerve-envelopes; in fact, their arrangement is so exactly like that of the best constructed electrical cables that we cannot help thinking that both were constructed to conduct something very much alike. I know there are those that stoutly maintain that nerve force is not electricity; and it is not, in the sense that an electrical battery is the same thing as a live man; but nevertheless nerve force is closely allied to that wonderful thing that for want of some better name and clearer understanding we agree to call electricity. In these latter days they photograph with electric light, and perhaps something analogous takes place within the brain. Each of its billions of starry cells may possibly hold within it photographic transparencies waiting for memory's lantern to restore them to us with all their original beauty and color. Thus each of us may carry about with us a picture-gallery like that of blind old Niebuhr, or Louis Philippe's state china which was decorated with views of all the homes in which he had lived, and they were many and various; for if we will we may paint every old pot and pan with the paintings of memory and imagination until they are fairer than Sevres china. "Make for yourself nests of pleasant thoughts," says Ruskin, and the happiest man is the one whose brain is full of such pleasant resting nooks; but what shall we say of the man or boy who fills his mind with Pompeiian pictures and vile thoughts, to keep them there for the rest of his life. He is a vandal, or worse, who would defile a king's palace in this way, and still coarser if it is his own home. Such pictures and stories burn into memory like a hot iron, and, unfortunately, they are so common that the White Cross League is needed fully as much here as in old England, where it originated. (See Appendix.)

To turn to another and pleasanter subject, let us look briefly for a few moments at our ears; for we have in the body no daintier adaptation of means to ends than that seen in the organs of hearing. We think the telephone a great invention, and so it is, but it is an old one—older than most of us think; for unless we do so stop to think we forget that each of us carries about with us a pair of telephones better than either the Edison or the pan-electric. Our ears, fortunately, are not so cumbersome as a Bell instrument; but if we examine them carefully we shall find the same principles underlying their construction which are employed in all the modern telephones. The essential parts of all of these are a vibrating plate and transmitting wires to carry these vibrations to some listener at a distance. Now this is essentially what we find our ears to be—true telephones, though constructed more delicately than any of those of man's make. Where, for instance, can you find a receiver as delicately fashioned as the external ear? At its worst it is a thing of beauty and most admirably adapted to the purpose for which it was made—namely, catching and conveying to the membrane of the drum of the ear as large a number as possible of the sounds about us. This membrane of the ear corresponds to the vibrating plate of the telephone, and is shaped, though smaller, exactly like the membranes used in the ordinary home-made telephone.

These membranes are shallow cones, with the apexes pointing downward and inward, and cover over a cavity in the hard bones of the skull to which the name of the drum of the ear has been given, not so múch to any fancied resemblance of its shape to a drum as to the fact that both ends of this cavity are covered with membrane very like the parchment or skin of a drum-head. This ear-drum has its sticks inside in the shape of three very small bones, to which the names of hammer, anvil, and stirrup have been given. These lie one upon another in such wise that the handle of the hammer is fastened to the apex of the cone of membrane which constitutes, as told you, the receiver of the

telephone. Every time this vibrates it drives the head of the hammer against its small bone-anvil, and the anvil in turn pushes against the stirrup, and the stirrup against the membrane at the other end of the drum. These little bones thus constitute a short circuit to carry sounds across the air chamber of the ear and transmit them to the membrane at the further or inner end of the drum. What becomes of these vibrations there? All sounds are due to vibrations of varying rapidity. (See page 169.) Now, these vibrations, traveling at their peculiar rate of speed, according to their pitch, at last reach this further end of the drum, or the *fenestra ovale*, as it is called, and passing through its membranous curtain are received in some curious little canals hollowed out of the hardest portions of the bones of the skull. In fact, so snugly are they packed away there that if once inflammation gets into these semicircular canals the pain and pressure are so great that it is enough to drive a man crazy—and it has killed many a man before now and crippled more children, especially those recovering from scarlet fever, where earache is one of the things especially to be dreaded. These little canals, of which we have been speaking, are so curiously coiled and twisted upon themselves that I despair of describing their shape to you even by a cut, picture, and diagram at the same time. Approximately they might in general be described as three tiny hoops and a something not unlike a snail-shell. These contain membranous bags filled with fluid, by which we are able to distinguish between the different qualities of sounds. How this is done is more ingenious in method than any telephone yet invented.

First, the semicircular canals. Their duty is to distinguish as to the quantity and intensity of sounds, and not as to their quality and pitch. This they do by wave impulses, set in motion by the moving to and fro of the stirrup, which, as we have already seen, takes place with every sound entering the ear. These semicircular canals are filled with a tiny water-tight sack exactly fitting it, one end of which is fastened to the foot-plate of the

stirrup bone. They are filled with fluid in which float some bits of sand, and into which fluid project long, delicate filaments which cover the terminations of the auditory nerves. Now, every time a sound reaches the membrane of the drum it causes this to vibrate. Its vibration moves the hammer, the hammer moves the anvil, the anvil moves the stirrup, the motion of the stirrup pulls forward the end of the tiny bag of water fastened to it. This motion of the bag sets its contents into waves, and these waves cast these bits of sand against the sensitive filaments lining the inside of the sac, and the impulse of this sand upon these filaments when transmitted to the brain along the nerves gives us there our perception of all soft and loud noises. Truly it seems a process as long as getting the maiden married in the house that Jack built, but really takes only the fraction of a second to accomplish it, but none the less wonderful on that account. The train of events is about the same in the "snail shell," except that there the vibrations pass up and down over something looking like a minature key-board, for on it are fastened a vast number of fibers, pointed at an angle like the keys of a piano, and striking not wires, as in a pianoforte, but nerve terminations. Most likely each one of these nerve ends, or keys, so to speak, represents a separate and distinct musical impression. As Huxley says, "Each fraction of tone which a well-trained ear is capable of distinguishing is represented by a separate nerve fiber." A tuning-fork or piano-string will, as you know, respond automatically to its particular notes when sounded in its neighborhood; so it probably is with these fibers of Corti, which, as it would seem, vibrate only in unison with their particular sound; that is, they ought to, but the aural piano-fortes of some men are so badly out of tune that they can scarcely distinguish "Old Hundred" from "Yankee Doodle," although otherwise their hearing is excellent. This was always a marvel to me until I began to understand the different duties laid upon the different parts of our ears. Unless there is some congenital defect we probably all hear alike until cultivation enables us to

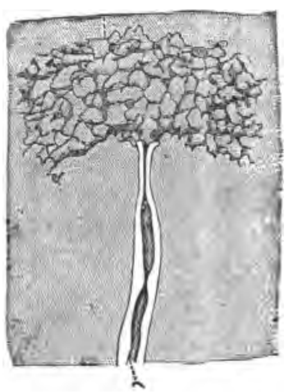
appreciate nice distinctions of sound. This reaches its highest perfection in the blind, probably not because they have any better hearing than the rest of us, but because their misfortune makes them continually cultivate their hearing, for like all of our faculties it is susceptible of very great improvement under cultivation. Vocal culture trains both the voice and ear at once. And yet, after all, there are vastly more sounds that we cannot hear than those that we can. Audible sounds are bound between the comparatively narrow limits of those too low or slow in their vibrations for human ears and those too high or rapid in their vibrations—like those that comes from a mosquito's shrill song in the night—which are too fine (high-pitched) to be caught by our dull ears. Some day we shall have our ears unstopped, and shall find out by actual hearing what it is that the stars literally sing together, for we live in the midst of a world of melody, very little of which ever reaches these mortal ears.

There is no organ we possess that we undervalue so generally as our ears; for, grievous as is blindness, it is really less of an affliction than deafness. Deafness so cuts off a man from the rest of the world, and, in spite of the old witticism to the contrary, most of us are not good company for ourselves. It is not good in any sense for man to be alone, and our ears are the most trustworthy means that we have of learning that there are such things as human sympathy and brotherhood in the world. There are more good men and women than we dream of, and the only way we shall ever learn to know them is through what we may hear them say. So let us take good care of our ears. They are dainty and exquisite instruments, and should not be stuffed with old cotton or filthy sponges under the pretense of cleaning them. A little soft cotton cloth gently twisted into the ear is all that ought ever to be used for cleaning them; for more injury, I think, is done by over-zealousness in this matter than by too little care. The external ear should of course be kept clean, but all poking or rubbing of the internal ear is bad, and often positively injurious to so delicate a piece of mechanism.

So delicate is it that as soon as any thing goes wrong it gives us very positive evidence of trouble by the sharp danger-signal of earache. It is too positive a symptom to be neglected, so that various remedies are tried until relief is found, and usually with this comes a discharge from the ear. This is generally slight, and there is so often no pain with it that it is considered a matter of no moment, and yet ninety per cent. of the cases of deafness that come to the doctors' hands are from this cause. Remember, no such discharge can ever be safely neglected—all the old women in the country to the contrary notwithstanding.

There is, I know, a popular prejudice to the effect that the stoppage of such a discharge is dangerous. Penning up foul matters in the delicate middle ear may lead to distressing headaches or even to brain-fever; but penning up such matters within the head is a very different thing from curing the cause—which is what should be done, and as promptly as possible; for the longer the delay the greater the difficulty in curing what, if left to itself, will certainly prove a life-long annoyance, if nothing more serious.

Finally, many a poor child gets a reputation for stupidity when the real trouble is deafness—not absolute deafness, but just enough dullness in hearing to make it slow to catch the teacher's exact words, and consequently miss his thought. The removal of a little hardened wax will often transform the dullest pupil into a promising one, who would have been misunderstood for years, unless some one had thought of examining his ears.



Reticulated end plate of nerve fibers.—*Klein.*

All our thoughts, impressions, delights, and sorrows, come, then, primarily from pressure upon tiny nerve-twigs, such as are here represented. More than all

else of our bodies they are the cause of our most exquisite joys and sorest pain, for they are the grand inquisitors set to reward and punish the knights templar of the body.

Thus far the body has been likened to a modern dwelling, constructed with all possible conveniences, but it is more than that. Truer psychology has never been reached than that found in the words of the apostle Paul, selected as the motto of this little book. The body was designed for more than a mere dwelling; it is a temple as well, wherein should dwell the knights templar—of the red cross and the white. Of all the tales of the age of chivalry none is more poetic than the story of the Knights Templar, a religious order founded in the beginning of the twelfth century, by Hugues de Paiens and other French knights. It originated at Jerusalem, and was designed to protect the holy sepulcher and the pilgrims resorting thither. The members of the order bound themselves to listen to the holy offices daily, and to practice fasting four days in the week. They were known as the Poor Soldiers of the Temple of Solomon, and at first subsisted entirely upon the scanty benevolence of the king of Jerusalem. Later, vast donations poured in upon them, and members of the most noble families in Europe thought themselves honored by being enrolled among the Knights Templar, and being allowed to wear their red cross upon their shoulders.

As elsewhere, the wealth and power of the Templars at last wrought their destruction, for their luxury, vices, and arrogance finally gave their enemies, Philippe IV., and Pope Clement V., and Edward II., a pretext for seizing upon the possessions of the Knights Templar and abolishing the order.

Doubtless, they had outlived their day of usefulness, and ceased to exist, as says another, because "they were rich and had nothing to do. They were an anachronism and a source of danger at the time of their dispersion," but they have left us many things worthy of remembrance and imitation.

The great seal of the order, two knights mounted on a

single horse, is not an inapt symbol of the tripartite nature of man—body, soul, and spirit. The beast well represents the body—essential for the accomplishment of work, and, when held in check, invaluable ; but, left unbridled, a very Mazeppa's steed to bear us to sure destruction. Hence the body is governed by two masters, mind and spirit, which some consider a sort of Siamese twins, but, whatever their exact relationship, they are the rightful governors of the house in which we live. We cannot live aright without their mutual advice and aid. A body directed solely by the mind becomes as polished a heathen as an educated Bramin, and one led by spirit alone gives rise to the vagaries of a Joanna Southcote. *Per contra*, John Wesley is an excellent illustration of what symmetrical development may do for man. John Wesley's spiritual insight was the marvel of his century and ours; but it should also be remembered that intellectually he was justly entitled to the fellowship which he received and held for many years at Oxford, while his body was so carefully cared for that we find him at eighty-four able to preach at five o'clock in the morning, and personally to attend to the annoying details of a church organization and publishing interests that in these latter days require the services of a board of bishops and a book committee to look after.

Such as John Wesley, in their measure, would all men be if they cared alike for mind, spirit, and body. The ideal man should be perfectly developed in all directions, for if any part of man is neglected it becomes stunted and useless. This we all know to be true in regard to mind and body, but when it comes to spiritual growth we find it too often neglected to its everlasting injury. "The soul that sinneth it shall die" is as much a part of the laws of the universe as the fiat that we must all die. We witness the death of the body so often that the fact cannot be denied, but a similar result in regard to the soul's death can be as certainly demonstrated. Our large cities are full of men and women whose souls have been dead in trespasses and sins for many years. There is no sadder sight on earth than a soul's corpse coffined

in the bloated wreck of a body. Alcohol does this. It is one of the arch Saracens against whom the body's knights templar must wage incessant warfare, as well as other fleshly lusts which war against the soul. The culture of the mind and spirit belong properly to psychology, except so far as they influence the health of the body. And this they do in no small degree. Just how this is done may be difficult to explain without falling into materialism, but the fact remains that soul and body are in this world mutually dependent one upon another. A well-balanced mind is rarely found except in a sound body, and there is a whole volume of theology in Mrs. Prentiss's candid statement that she never was in religious gloom except when she had eaten something that did not agree with her. No better, or more devoutly pious, woman than the author of *Stepping Heavenward* ever lived, but she was honest and clear-sighted enough to discover that her "experience," not religion, was largely conditioned by her body's health. Similarly, the health of the body is at its best when the mind and spirit are happily employed. For physiological reasons, if no other, a consistent, well-educated Christian ought to be the happiest man living, if sound in mind, body, and conscience, for he has learned how to use all his "talents" to their best advantage, and has ceased to take worry for the morrow.

"Worry," far more than overwork, is the cause of the frequent ill health and the premature breaking down so common in our large cities. The haste to be rich, debt, and anxiety about money matters whiten more heads and wrinkle more faces than disease. Any occupation which keeps one oscillating between hope and despair inevitably disturbs the innervation of the body so that digestion is ruined (see nervous dyspepsia, page 83), and sleep becomes a lost art. Little wonder, then, that under these circumstances the general nutrition of the body fails, and the man or woman breaks down, it is said, of overwork. Worry would have been the true verdict, for, as well says the *Saturday Review*, "A professor may labor at the search for the absolute for

fifteen hours a day and be all the better for it, while a third of that time spent in the ups and downs of the stock exchange would qualify him in less than a year for the strait-jacket or halter. . . . Complaints of overwork are among the flimsiest of all excuses set up by men for the evils they have brought upon themselves. Very few people really work hard, and when they do it generally agrees with them. Directly and indirectly, idleness does fifty times as much mischief as overwork. A vast amount of good pity is thrown away in the world, for when the danger really exists it may generally be remedied rather by redistributing the burden than by diminishing it." In short, the danger in overwork is generally not in the amount of work, but in bad habits of work. Hurried work, work at the wrong time, and, more than both, worry over the future bring men to untimely disability in the ways already mentioned.

The remedy for these evils may be found in systematized work, in "do the best and leave the rest," and, most of all, in the biblical advice to take no thought (worry) as to what we shall eat, drink, and wherewithal we shall be clothed; not the least important of which is the last, for the desire to follow the fashions in clothing drives more into debt than all other causes, and debt means, except to the absolutely unprincipled, distressing mental worry and strain. Debts are the most frequent causes of insanity and suicide, for nothing more surely upsets the whole mental balance than long-continued and pressing debt. A mortgage, etymologically, means a death-grip, and too often it is literally that as well, from the effect that it exerts upon the health of the body by depriving it of hope, rest, and cheerfulness.

How it is that the mind is able to affect the nutrition and health of the body we do not know, but the facts are beyond all dispute in many cases. Indeed, it is often possible for a man to be seriously injured during the excitement of battle, and pay no heed to it until after. Mr. J. B. Gough permanently injured his hand during a lecture, but did not discover the fact until the close of his speaking. Such cases

are but those of deferred or diverted attention, for no sooner is the excitement removed than the pain is felt. The same, in a measure, is undoubtedly true of the religious enthusiasts of the East who prostrate themselves upon the ground to allow themselves to be ridden over, or thrust sharp skewers into their cheeks and red-hot nails into their palms apparently without pain. The history of all people is full of instances where religious excitement and the contagion of example have rendered enthusiasts for the time being insensible to ordinary suffering. The priests of Baal cut themselves with sharp stones in the frenzy of their false religion, as the flagellants scourged themselves in the Middle Ages. Similar performances may be seen at Mecca, and at some of the East Indian religious festivals; for, in all great gatherings of people little accustomed to self-control, excitement and the imitative faculty lead to strange actions. The same cause that induces others to gape by the suggestion of our yawning produces many a strange antic in those not able to keep the mastery over themselves. To this impulse the name of suggestion has been given, and to its operations we probably owe the phenomena of mesmerism, hypnotism, and the marvels of so-called clairvoyance and mind-reading.

Mesmerism, so named from a Dr. Mesmer, who first investigated the subject, was the term originally used for the hypnotic condition, or a state of apparent sleep in which the will of the one mesmerized is to all intents and purposes put into the hands of the one producing the hypnotism. Thus hypnotized the victim will sing, cry, dance, preach, or pray, as the mesmerist wishes, until the spell is broken. Fortunately, not all can be thus hypnotized, and probably none can be made susceptible against their will. The mental mechanism of hypnotism has never been definitely determined, but it seems reasonable to believe that it is a condition of affairs in which the will is held in abeyance and the brain left to act solely by suggested thoughts. Imagine, if you please, a ship with its helmsman drugged but still able to stand at the wheel and automatically to do the bidding of some one who stands be-

hind him, and you have a fair comparison to illustrate this hypnotic condition. It is useless and harmful, for it has never been productive of any valuable results, and tends to weaken already impaired will-power, and might be utilized for actual crime. Experimentation in this line should be strongly discouraged, for it can bring out no new facts and may inflict serious injury—moral, if not physical.

Clairvoyance, beyond a doubt, is another manifestation of this same impulse, for, behind all the arrant fraud of the majority of the so-called clairvoyants, there is a power possessed by some of following most ingeniously the suggested thoughts of the questioner—only that and nothing more. A careful study of their most wonderful exploits will show, so far as the writer has been able to inform himself, only reproductions of thoughts or facts known to the one seeking the clairvoyant's aid. Many of these thoughts may be but dimly remembered, but if false, or falsely recalled, the clairvoyant falls into the same mistake.

Catherine Beecher years ago carefully investigated the subject, and her results are the same as those obtained by all candid investigators. We quote her experience in her own words:

"Early in December, 1844, having heard, through most reliable persons, of the performances of a clairvoyant woman in Boston, I wrote to my family friends in various States, east and west, that I should go to that city on the 23d day of that month, and visit this woman between the hours of 9 and 12 A. M.; and I requested them all to note down what they were doing at that time, and also to write a sentence and lay it on the mantel-shelf of their sitting-rooms.

"I went on that day, no person in the city knowing that I was to be there. I went from the cars to this woman, whom I had never seen. None of her family knew me or I them, and I did not give my name. She was put in the clairvoyant state, and then I was left alone with her."

Without giving in detail Miss Beecher's conversation with the clairvoyant, which may be found in her *Letters to the*

People on Health and Happiness, it is sufficient to say that the clairvoyant described correctly every minute particular concerning certain houses and their occupants in Hartford with which Miss Beecher was acquainted, but entirely failed in a crucial test thus proposed by Miss Beecher:

"I then asked her to look on the mantel-shelf below, and see if there was a paper with writing on it. She then continued thus: 'There is some writing pinned to the wall over the mantel. It is too small. It ought to be written larger. You told them to do this. The first words are: "*The baby's name is*—" I cannot read it, it is too small.'

"'*Try!*' said I, with greatly excited interest. She grasped her hands tightly together, and shook all over, as if making a great effort. Then she said, 'Yes, I see it. It is written, "*The baby's name is George.*"'

"Now every minute particular as to the people, house, and furniture corresponded with my past experience. But this matter about the writing was all concocted by herself from materials in my past knowledge. For the baby's name was not George, and there was no paper prepared as I had requested. Nor was I conscious of thinking that the child, if a boy, would be called George after the child that was dead. Indeed, I should not have supposed that this would be the case."

Such mental echoes add nothing to the sum of human knowledge, and are dangerous from their opportunity to fraud, as has been over and over again proven. There may be honest clairvoyants and spirit-rappers, but their feats are performed under surroundings better adapted for fraud than any professional magician would ask. Many of the tricks of these so-called mediums are startling, but they have all been duplicated and excelled by those who make no pretense of any higher powers than sleight of hand.

Dreams are less explicable than the clairvoyant's feats. The latter, deprived of the gross amount of fraud mixed with the larger part of them, are, when any thing more than fraud, the interpretation of another's thoughts into the

medium's words. Hence it is that the hypochondriac is sure to find "the seventh son of a seventh son" agreeing with him in his own ideas of his ailments, even if unexpressed. Those that agree with us we are ready to adjudge wise, and hence the number of victims who fall ready prey to these. But whence come the suggestions from which originate dreams, and why do we dream at all? Sleep has been defined by some one as the victory of the sympathetic over the cerebro-spinal system. Less technically, it may be said to be brain and body rest, produced most probably by a periodic lessening of the supply of blood sent to the brain. Eating a hearty meal attracts the blood from the brain to assist in digestion, and hence the drowsiness that comes to many after a full meal. Perfect sleep is "sore labor's bath, balm of hurt minds, chief nourisher in life's feast," and should be dreamless, or that from which we awake without remembrance of having dreamed. Thought, memory, and conscience ought all to slumber when sleep "knits up the raveled sleeve of care," but too often mind and spirit labor too, while the wearied body is trying to sleep and we dream.

Dreaming is, then, involuntary mental action, while the body is cut off from its ordinary avenues of sensation. So we often say and think, and yet it is more frequently true than we think that dreams are bodily sensations misinterpreted by the dazed and bewildered brain. For instance, Dr. O. W. Holmes says: "I once inhaled a pretty full dose of ether with the determination to put on record at the earliest moment of regaining consciousness the thought I should find uppermost in my mind. . . . The veil of eternity was lifted. The one great truth which underlies all human experience, and is the key to all the mysteries which philosophy has sought in vain to solve, flashed upon me in a sudden revelation, . . . and staggering to my desk I wrote in ill-shaped, straggling characters the all-embracing truth still glimmering in my consciousness. The words were these (children may smile; the wise will ponder): 'A strong smell of turpentine prevails throughout.'"

And why should not both children and wise men smile? for the witty doctor had scribbled his ludicrous sentence while he was but half awakened from a grandiloquent dream, produced by the pungent odor of the ether. Thought works with almost inconceivable rapidity in the case of these suggested dreams. The report of a gun may between the time of its sound and the awakening of the dreamer give rise to a three volume novel in the mind of the sleeper. It is almost incredible what a multitude of ideas may under certain circumstances follow each other with surprising celerity. What books we have written, what orations delivered and dramas enacted in our minds, while we are vainly trying to grasp the idea that it is time to get up, or shivering from an exposed limb, or uncomfortable from dining not wisely, but too well. The last is extremely prone to produce unpleasant dreams—nightmares, so-called, though why it is hard to say—from the annoyance of the undigestible food, mistaken, perhaps, by the half-awakened brain for the prince of darkness sitting astride the dreamer. Eating a light meal just before retiring does not interfere with sleep, provided the food is such that it is easily digested; for, as has already been said, normal digestion aids sleep, and a late meal is the best treatment for the insomnia of night and brain workers.

Not a little valuable literary work has been done in sleep. Coleridge's *Kubla Khan* was thus written, as was Tartini's *Devil's Sonata.* One of Lord Thurlow's best Latin compositions was thus dreamed out and Cordorcet and Franklin—happy men!—were said to have been able to work out elaborate mathematical calculations after the same fashion. In these cases, as in the mathematical prodigies which are occasionally met with, the brain undoubtedly acts automatically, like one of the patent automatic adding machines. In the innumerable multitude of dreams it would be strange if some of them did not occasionally come true, and probably every one has had such coincidences in his own experience. History is full of notable examples, as the famous one of the Prince of Condé, who dreamed just before the battle of

Dreux that he engaged in three battles, in which he was successively victorious, and that his victories would cost his enemies their three chief officers; and that after these victories he himself should be slain; all of which was afterward realized exactly as dreamed. There is a copious literature on such realization of dreams, and of the appearance of those dead, about the time of their death, to dreaming friends, whose discussion belongs to psychology rather than physiology, and must be here dismissed with the thought that there may be "more things in heaven and earth than are dreamed of in our philosophy."

The explanation of somnambulism is less difficult, for sleep-walking is a sort of intermediate station between hypnotism and dreaming. It differs from the first in that the actions performed are voluntary with the one performing them, and differs from dreaming in that the acts are actually done, and not merely willed, as is the case in dreaming. In the latter we have the combined action of the will and the imagination only, while in somnambulism we have the assistance of the voluntary muscles as well. The sleep-walker usually has absolutely no remembrance of what he has done; occasionally he will remember his performances as those of an unusually distinct dream, unless he is suddenly awakened in the midst of his actions, when he generally is unable to give any rational account of himself. Some of the exploits of somnambulists are so extraordinary that they can hardly be explained—except upon the theory of a sixth sense, which takes cognizance of form and distance without sight. How otherwise, for instance, can be explained their perilous night walks with safety along the ridge of a roof where one could scarcely venture with his eyes wide open? More remarkable are the apparently well authenticated cases of letters written, pictures drawn, and needle-work done accurately in the dark by somnambulists, who for the time were like the idols of Scripture, in that having eyes they see not, in the ordinary acceptation of the term, and yet are able to work as if they were blessed with the keenest of sight.

Another strange mental freak is that of dual existence, so called, in which the person thus afflicted leads a double existence for a part of the day or week, being entirely unconscious of what was done in the other half of his existence, but able to take up the change of thought and work with the passage from one condition to another. Such cases, fortunately, are rare, and, if explicable at all by physiology, are explained by an independent action of the two halves of the brain.

Possibly these are simple cases of intermittent memory, from whose lapses we all suffer. It is doubtful if we ever forget entirely any thing which we ever thoroughly knew, but men differ greatly in their ability to recall desired information. Often the harder we try the less successful we are in our efforts, so that often the best way in which to accomplish our end is to allow the brain automatically to work out the problem for us. Napoleon said that his mind was a case of drawers, of which he could pull out or shut up any one as he desired; but the mental chiffoniers of many men have become wedged from disuse. Fortunately, the brain will coax open these refractory drawers if we will but give it time. Quietly, and unconsciously to ourselves, the lock is at last turned, and the desired fact lies open to our scrutiny. Such seems to have been the process by which Sir William Hamilton discovered the relation of quaternions. "I was walking," says he, "on the 15th of October, 1843, with Lady Hamilton, when on reaching Brougham Bridge I felt the galvanic circle of thought close, and the sparks that fell from it were the fundamental relations between i, j, and k." This is done by unconscious cerebration, begotten of repeated practice.

The great value of all education lies in the fact that we can at last do with facility what at first was difficult and painful. The school-girl laboriously fingering "Days of Absence" may, if she please, learn to play almost unconsciously most difficult music and keep her mind fixed upon other subjects at the same time. So it is with knitting, type-setting, stenography, or any pursuit which requires manual dexterity; and the

same in a measure is true of intellectual work, in which practice is all important. Anthony Trollope's financial success as a novelist was due to his invariable practice of writing daily twenty-five hundred words of a projected story, no matter where or what his surroundings were. This he did in the midst of a busy official life, which many another man would have thought more than sufficient for his waking hours. Thackeray, with far more genius, was always in the drag with his writings and finances, simply because he had never learned Trollope's habits of literary thrift.

"Habit is second nature, and man is a bundle of habits." Habits of some kind we must have; all have some more or less useless and ludicrous. Schiller thought he could not write well unless he had the odor of rotten apples in his room. Dr. Johnson must touch each lamp-post as he swayed along the streets of London, and—but who is there who has not some odd trick of gesture or manner that he carries with him through life? The vast majority of these habits are formed between twenty and thirty, or, as Lord Collingwood put it, "Before you are five-and-twenty you must establish a character that will serve you all your life;" for fortunately good habits become as strongly fixed as evil ones, of which we hear vastly more. "Habits are a necklace of pearls," says the Russian proverb, and such they are if they are habits of self-respect, self-help, industry, integrity, and decision. There is, says the *Popular Science Monthly*, "no more miserable being than one in whom nothing is habitual but indecision, and for whom the drinking of every cup, the time of rising and going to bed, and the beginning of every bit of work are subjects of express volitional deliberation. Full half the time of such a man goes to the deciding or regretting of affairs which ought to have been so thoroughly ingrained in him as practically not to exist for his consciousness at all."

The great thing, then, in all education, is to make automatic and habitual as early as possible as many useful actions as we can. The more of the details of our daily

life we can hand over to the infallible and effortless custody of automatism the more our higher powers of mind will be set free for their own proper work." Habits, if good, are conservative and helpful even though they may seem ludicrous to others with their different ways of thinking and doing. Bad habits degrade by destroying little by little self-respect, until at last their victim is bound in chains that he finds himself unable to break, for habit has wound itself about him until it has become an integral part of himself.

The comfort or wretchedness of our residence in this house in which we live turns largely upon our habits—personal, mental, and moral. If they are those of Peter the First, the man is an animal—that is all. His stable may be decorated with all that the wealth of the Russias can buy, but after all it is a stable, and no amount of whitewash or outside gilding can make it any thing else. Nor is the body designed merely for a literary work-shop. A library is a more enjoyable spot than a menagerie, but the body was given to us for other purposes than mere culture. Culture is better than barbarism, but culture is not God, and men and women were born to worship God, not culture. The only satisfactory explanation of the body is that given by St. Paul, already quoted; namely, "Know ye not that ye are the temple of God, and that the spirit of God dwelleth in you. If any man defile the temple of God, him shall God destroy, for the temple of God is holy, which temple ye are."

Science and revelation join hands over this declaration of the apostle. The body is too magnificent a piece of workmanship to lodge an animal. It is fit to be the temple of its maker. It ought to be, or it misses pitifully the end for which it was built, and with the failure comes the penalty. Whatever science may fail to corroborate in the way of revelation, it is not at the point of penalty. "Whatsoever a man soweth, that shall he also reap," is the emphatic teaching of science, and nowhere is this more pitilessly true than in regard to certain sins against the body. It is literally true that such sins bring certain destruction to those who thus de-

file the temple of God. It would be far pleasanter to pass such by without mention, but their frequency forbids. Bad men and women, and worse pictures and books, abound for the avowed purpose of defiling the temple of God with worse than Pompeiian frescoes; and the time has come when it is no longer right to keep silence on temptations which menace even the school-boys and girls of this country. The evil cannot be met too early, nor too fiercely. Its aims are diabolical, and its results are such as to make the angels weep. The large majority of fallen men and women go astray before they are fourteen. Ignorance is not safety, for the only way in which this evil can be met is by conjoined effort—mothers with daughters, and every brave, pure man and boy in the White Cross League. The Knights of the Red Cross fought to save from desecration the holy sepulcher; the aim of the Knights of the White Cross of to-day is to save from defilement the "temple of God, . . . which temple ye are."

There is a touching little story in mediæval Latin of a sick pauper who came to the operating room of a renowned surgeon of those days. The great man, who thought he could not waste his time on so poor a patient, turning to his assistant said, "Experiment on this vile body;" whereat the poor wretch—for it was before the days of anæsthetics—pleaded, "No body is vile for which Christ was not ashamed to die." "*Corpus non tam vile pro quo Christus ipse non dedignatus est more,*" might be well chosen for the motto of the modern White Cross Knights, who already number many thousand, although their organization dates back only a very few years. The disappearance of the knights of the age of chivalry has left a need of like self-sacrifice and devotion by some similar brotherhood. This the White Cross Knights promise to fill, making, if possible, social purity as binding upon man as woman. The White Cross obligations, as may be seen, are few and simple, and all true men and women should bid them Godspeed in their efforts to make the world better and purer.

WHITE CROSS OBLIGATIONS.

My strength is as the strength of ten,
Because my heart is pure.

"I promise to treat all women with respect, and to endeavor to protect them from wrong and degradation.

"I promise to endeavor to put down all indecent language and coarse jests.

"I promise to maintain the law of purity as equally binding upon men and women.

"I promise to endeavor to spread these principles among my companions, and try to help my younger brothers."

CHAPTER VIII.

MOTH, RUST, AND MICROBES.

IT must not be forgotten, in our study of the human body, that it is a chemical compound as well as a complex piece of machinery; or, rather, the organs and parts of a human body, like every thing else material, are composed of molecules and subject to the laws which govern them. And what are these molecules? The word means literally a little mass, but is used in chemistry and physics with the more exact meaning of a little mass composed of two or more atoms. "A molecule," says Tidy, "is the smallest possible cluster of atoms existing as a compound and capable of having an independent chemical action." The molecules are then, according to these definitions, composed of atoms, and this leads us naturally to inquire in what atoms differ from molecules. The name will help us to an answer. Atom is from the Greek, and means uncutable. The atom is then the uncutable or indivisible part of the molecule, for it is at least possible to think of dividing matter until its further division becomes in thought impossible. The results of the last divisions of all matter are what are called atoms. One might think, from the infinite variety of matter with which we are acquainted, that there would be an infinite variety of atoms, but chemists believe that there are as yet not more than seventy different kinds of atoms known, although these are found linked together in an almost infinite number of molecules. In the molecule the atoms are supposed to be held together by chemical affinity, and the molecules are influenced by other forces. These molecules, or tiny groups of atoms, even in the firmest stone, are supposed never to be absolutely quiet, but are swaying to and fro with a motion

varying in rapidity with their attraction or repulsion toward each other. If this attraction is strong, they constitute a solid in which they can be lifted together in mass; if their attraction is less, but still such that they have a certain amount of cohesion, the molecules then form a liquid; but if there is absolutely no attraction between the molecules, but repulsion, they constitute a gas. Heat is supposed to increase the repulsive powers of molecules, and hence heat will transform a liquid into a gas, as we do whenever we boil the water in the kettle. Cold acts in an exactly contrary way, for cold drives the molecules nearer together, and thus transforms liquid water to solid ice.

The solids, liquids, and gases of the body are subject to the same laws of physics and chemistry as matter elsewhere, with the single exception of that strange thing we call germinal or living matter. This may be killed by heat, strong acids, alcohol, and a variety of other agents, but then it becomes dead matter and subject to the laws of dead matter. So long as it lives it is vital, and resists the forces and powers which incessantly assail it. The wonder, then, is not that we die, but that we are able to live, beset, as we are, within and without, with foes begotten of our own bodies. Resurrection, Hume claimed, is too great a miracle to be believed on any amount of testimony; but modern science declares that life is more marvelous than resurrection, for the power requisite to set the perfectly prepared machinery to running again is feeble compared with the intelligent foresight necessary to protect it from the ceaseless assaults of invisible foes. Man is in exactly this condition, constantly beset by an innumerable army of molecules and microbes, which no man can see, but which are none the less persistent in their onslaught, until at last the vital tissues give up the unequal contest and die, as did Arnold of Winkelreid. This defeat we call death; and we should discriminate, as Huxley has done, between the forms of death met in the body. There is:

1. "*Local death,* which is going on at every moment

and in most, if not in all, parts of the living body. Individual cells of the epidermis and of the epithelium are incessantly dying and being cast off to be replaced by others, which are as constantly coming into separate existence. The like is true of blood corpuscles, and probably of many other elements of the tissues.

"This form of local death is insensible to ourselves, and is essential to the due maintenance of life. But, occasionally, local death occurs on a larger scale, as the result of injury, or as the consequence of disease. A burn, for example, may suddenly kill more or less of the skin; or part of the tissues of the skin may die, as in the case of the slough which lies in the midst of a boil; or a whole limb may die, and exhibit the strange phenomena of mortification.

"The local death of some tissues is followed by their regeneration. Not only all the forms of epidermis and epithelium, but nerve, connective tissue, bone, and, at any rate, some muscles, may be thus reproduced, even on a large scale. Cartilage once destroyed is not restored.

2. "*General death* is of two kinds: *death of the body as a whole*, and *death of the tissues*. By the former term is implied the absolute cessation of the functions of the brain, of the circulatory and of the respiratory organs; by the latter, the entire disappearance of the vital actions of the ultimate structural constituents of the body. When death takes place, the body, as a whole, dies first, the death of the tissues sometimes not occurring until after a considerable interval. (See page 47.)

"Hence it is that, for some little time after what is ordinarily called death, the muscles of an executed criminal may be made to contract by the application of proper stimuli. The muscles are not dead, though the man is."

Local death is generally painful, for its efforts are conservative and look toward the repair of the injured part. General death, as a rule, is painless at the last, for here as elsewhere nature is merciful as well as just, and does the kindliest thing possible for our best good. Mr. Beecher,

when asked how he expected to feel when he came to die, answered, more truthfully than piously, "Stupid." And it is to this merciful state, whatever may be the apparent agony of the last moments of dissolution, that we at last all come.

General death comes in one of three ways, says Bichat; either death beginning at the heart, death beginning at the lungs, or death beginning at the head. The last is in reality death from failure of circulation or respiration, or both, from injury to the centers located in the brain. In all such cases there is failure, due either to the heart or lungs, to properly aerate the blood. Failure to obtain sufficient oxygen results in an undue accumulation of carbon dioxide in the blood, and carbon dioxide is as truly an anæsthetic, in poisonous quantities, as is chloroform. The poison may produce convulsive movements most painful to witness, but their presence is conclusive proof that the dying man is already narcotized beyond pain. The "king of terrors" is most frightful to those who walk through the "valley of the shadow of death," but at last his arms are as tender and soothing as a mother hushing her tired child to sleep. The moral questions which may have been left unanswered until death may prove the source of the most torturing anguish, but at last there comes merciful oblivion. One with many opportunities for observation on this subject says:

"I have talked with persons who have been poisoned, or who have poisoned themselves, and who may be said to have died, inasmuch as they have fully decided and expected to die. They very rarely suffered in body or mind, and they lost their senses as gradually as when laying their head upon the pillow at night. Whatever pain they had was not in going from but in coming back to life, which would make it seem that the arrowheads, directing to death, wound only those anxious to return. We have on record the ante-mortem diaries of men who, having swallowed poison with the deliberate purpose of suicide, had wished to leave a record of the effect upon themselves of the conscious approach of death.

Most of these diaries show the surprise of the writers at the total absence of the awe or fear commonly believed to be inseparable from such circumstances. Doubtless the determination of self-extinction had absorbed the anticipated strangeness, and discounted the impressiveness and solemnity of the mortal occasion. It is natural to die, but hardly natural to desire to die. To will to die is all there is of death. To be killed outright by a gun-shot wound must certainly be easy. I have seen so many men slain in battle that I am sure of this. I have narrowly watched officers struck when leading a charge. Their faces evinced startled surprise, not anguish, and their nervous system received such a shock that, before sensation could rally, they had ceased to breathe. To say that a man suddenly put out of life by violence does not know what hurts him is exactly true. He is dead without thought of death, and therefore spared all mental apprehension, which is the worst part of dying. Abrupt death by external agencies must be very analogous to the shock from a Leyden jar."

Nor is death an exception to the general law that pain is conservative. Pain is the alarm given us whenever the foes of the body are assaulting it with dangerous intent. It is the signal that the line of battle is giving way somewhere, under the combined pressure of earth, air, fire, and water; for against all these man must incessantly fight. Hunger, fatigue, cold, and thirst are points at which these enemies crowd the closest, and where, if relief is not quickly brought, defeat is certain. Hunger is the irrepressible clamor for the fruits of the earth, which must be wrested from it at the point of the spade, hoe, and the knife, or we die. Fatigue is the inevitable result of the attraction of gravitation, that is, the ever-present weight of our bodies, conjoined to the atmospheric pressure of fifteen pounds to each square inch of its surface. So accurately is this adjusted we never notice its pitiless persistence until the wearied limbs at last succumb. Fire is at the same time man's best friend and most inexorable creditor. Fire is essential to civilization, but civiliza-

tion demands its pound of flesh for every forfeited bond, and these are many, for modern society demands that man shall give many a pledge to fortune. Even water, without whose aid we must perish in a few short hours, may serve, as we have seen (page 70), to introduce within the camp the most treacherous of enemies. Gravitation, oxidation, and poisoning from within and without are some of the foes against which this warfare must constantly be waged. To these must be added another, and, until recently, an unsuspected, foe of man—the *microbes*; a barbarous sort of Greek word, invented to name forms of life too minute to be seen except by means of the microscope. The part that these tiny beings play in fermentation, decomposition, and disease was little dreamed of fifty years ago. Within that time these tiny points, less in size as a rule than the red blood corpuscle, have revolutionized all our ideas and theories in regard to putrefaction and practical hygiene, and bid fair to do the same in the domain of practical medicine.

The causes of the decomposition of the human body after death were vainly sought for by the ancient philosophers and physicists, of whom none came nearer the truth than Van Helmont, who attributed it to the loss of *l'archée*, or, as we now call it, vital force. He was also the first to appreciate the relation between the air and putrefaction, for an organic body, entirely preserved from contact with the air, under proper precautions, can be preserved indefinitely. These facts were apparently well known to the Egyptians, and utilized by them in the preparation of their mummies, and also by the Ethiopians, if we can believe Herodotus's tales in reference to the preservation of their dead in glass. Under ordinary circumstances exposure of a body to light, air, and moisture accomplishes the dissolution of its soft parts entirely in from two to three years, and in so far as air is excluded is the process delayed. This was strikingly shown in the bodies of the Etruscan kings found some years ago in their sepulchers, where they had been preserved, protected from the atmosphere, unchanged for hundreds of years; but

no sooner was air admitted than these bodies began to crumble, and in a few hours were converted into unrecognizable dust. The same principle was applied to the preservation of food by the Romans, for canned fruit has been found in Pompeii, but its secret was forgotten until a little more than a hundred years ago, when Benjamin Appert demonstrated that meat sealed in air-tight boxes, after being heated so as to expel the air, would keep for an indefinite length of time at ordinary temperatures. On this depends the modern extensive use of canned meats, for it is well known that, after having been heated and sealed up in air-tight cans, and thus protected from the atmosphere, meats will remain sweet and fresh as long as the receptacle remains air-tight. For many years it was supposed that the oxygen of the air was the sole cause of the spoiling of meats and fruits; but it must be remembered that the oxygen of the air is not the sole cause of putrefaction, for it has been over and over again proven that, while air is apparently necessary to begin decomposition, it is not essential to its continuance after it has once begun; and hence the failure of hermetically sealed coffins to prevent decomposition. The explanation of this is found in the fact that putrefaction largely depends upon microscopic microbes and germs constantly floating in the atmosphere, whose growth and multiplication take place whenever they are deposited by the air in an appropriate soil or fluid, among the best of which are the fluids of the body. With a good microscope (1,200 diameters) multitudes of microbes may be found in the mucus which can be scraped from the inside of the cheeks or lips, as spherical or oval particles with multitudes of delicate filaments. The numbers and rapidity of multiplication of these bacteria with proper food is almost incredible, for Cohn has shown that bacterial reduplication can arise in the course of about an hour. At this rate a single bacterium would produce two in one hour, these by doubling would increase to four in the second hour, and so on until in the lapse of three days the scarcely conceivable figure of

4,772,000,000,000 would be attained. Whence do they come? Formerly it was believed by spontaneous generation from decaying matter, for the ancients entertained the wildest ideas in regard to the origin of life. Virgil believed that bees were produced from entrails, and Lepidus that mud and heat would generate crocodiles. For a long time it was believed that certain birds grew upon trees, and that the flesh of a duck could give birth to an owl. Similarly, serpents were supposed to originate from the spinal cord, and mice to be spontaneously begotten by sawdust and old rags. Even in our own times there are many intelligent people who believe that a horsehair left in the waters of a brook will be transformed into the thread-like worm that bears its name, and that maggots are spontaneously generated in decaying meat, although two hundred and twenty years ago Francesco Redi settled the question definitely. Like others, he had seen the maggots begotten in putrefying flesh, but unlike many others he observed that flies invariably were found also about the meat, and that they frequently alighted upon it. Surmising that there was some causal relation between these flies and the maggots, he covered meat with paper, and afterward with fine gauze, and found that no maggots were developed—naturally enough, for it is well known to-day that maggots are the half-developed progeny of flies.

These facts were soon overshadowed by the greater discoveries of Leeuwenhock, a Dutch microscropist, who discovered the yeast plant and certain animalculæ, as he called them. He was also the first to understand that the turbidity which occurs in animal and vegetable infusions was due to the growth of these minute forms of life, about which immediately sprang up most vehement controversies. These at first were mainly about fermentation, for although the yeast plant was discovered and figured by Leeuwenhock as early as 1680, yet its true nature was not definitely understood until it was rediscovered and explained in 1836 by Cagniard de la Tour.

Lavoisier and other chemists had previously studied attentively beer-yeast, or the plant which produces alcoholic fermentation; but it was reserved for Cagniard de la Tour to demonstrate its real nature. He proved that yeast is composed of granules of albuminous matter, which, when introduced into a saccharine fluid, there grows and reproduces itself. This is done by gemmation, as it is called, that is, by the growth of buds on the surface of the yeast plant. These again bud, and in turn produce new yeast plants. Yeast ferment is living, since the plants multiply themselves, and absorb oxygen, give off carbon dioxide, and produce alcohol from the sugar during the process. De la Tour furthermore proved that if the saccharine fluid does not contain albuminous matter fermentation still takes place, but the yeast plant exhausts itself in the process, and none remains to begin it anew elsewhere. The next question was, Whence came this yeast plant? for fermentation takes place in grape-juice whether the yeast plant be added to it or not.

Becker much earlier had taught that a dead body attracts microscopic eggs from the air, and that these were the cause of its decomposition. These theories and that of an astral fire and the balsamic spirit of the blood, which resisted putrefaction in the living body, were considered the wild dreams of a theorist rather than practical realities, until Schwann, many years later, demonstrated that these microscopic eggs, or spores, as we now call them, had a definite existence, and that to them we owe the changes produced by fermentation and putrefaction. That these spores are always present in the atmosphere was demonstrated by allowing boiling infusions to communicate with the air, but in such a manner that no air could enter the flask without having first passed through a red-hot glass tube, and been thus freed from any germs that might float in it. In this case the air had fair play, in a chemical sense, but yet no life of any kind made its appearance, and even the chemical changes failed to set in. Exactly similar results were obtained by Schwann in experi-

ments with grape-juice, whether previously mixed or not with yeast. These experiments demonstrate the fact that the process of putrefaction is not only analogous to fermentation, but that putrefaction cannot take place without the access of the living germs constantly floating in the atmosphere. But he carried his experiments still further. For instance, he found that white arsenic (arsenious acid) and corrosive sublimate, being poisonous both to plants and animals, stop both putrefaction and fermentation, while extract of nux vomica, being destructive to animal but not to vegetable life, prevents putrefaction, but does not interfere with vinous fermentation.

Justus Liebig published a memoir in 1848 upon the subject of fermentative changes, in which he reviewed and brought into a more definite form Schwann's theory. He, too, considered all fermentations and putrefactions as analogous phenomena, but considered yeast a "purely accidental phenomenon" in vinous fermentation, and thought its power of promoting the fermentative process was owing to the unstable albuminoid substances it contained.

Schroeder and Dusch, in 1854, proved by an extensive series of experiments that the something in the air which enables it to start fermentative changes in boiled infusions of meat, etc., can be effectually removed by filtration of the air through cotton-wool.

Such experiments, carried on through the first half of the present century, proved that the intervention of air was not indispensable to putrefaction, but that the contact of a ferment with a putrescible body was sufficient to bring about the decomposition of the latter. Gay-Lussac combated this opinion, and attempted to prove that without air or oxygen vinous fermentation could not begin, for, said he, grape-juice shut off from access to the air, as in a test tube over mercury, does not undergo fermentation; but if a few bubbles of air or oxygen are passed into it, fermentation begins, and manifests itself by the evolution of carbonic acid gas, and this gas occupies exactly

the same volume as that of the oxygen which has been absorbed.

Louis Pasteur first carefully discriminated between true ferments and the germs of ferments. Atmospheric dust is made up, in the greater part, of earthy matter mixed with organic debris; to wit, microscopic spores and infusorial eggs, which latter are, according to Pasteur, the prime agent in decomposition. Oxygen is not the motive agent in these decompositions, as affirmed by Gay-Lussac, neither do the nitrogenous atoms of the atmosphere play the important part in decomposition, but these minute organisms which possess a frightful power of multiplication. Moreover, he showed that the oxygen of the air is powerless to bring about these alterations if the corpuscles that it usually contains are eliminated or incinerated. In 1864 the French Academy chose from itself a commission which repeated the experiments of Pasteur and proved their exactness by taking a flask filled with calcined air and attaching it to a tube, whereby a partial vacuum may be produced. By a proper arrangement blood was drawn from a living animal directly into such a flask without coming in contact at all with the air; and such blood does not undergo putrefaction, provided the air in the flask has previously been brought to a red heat.

Further experiments conclusively proved that the development of putrefaction took place, not from the gaseous elements of the air, but from something that they allowed to fall from them in a vertical direction, for a sterilized fluid placed in a flask with a long neck laid sideways did not undergo putrefaction until the neck was allowed to stand upright and open to the air. To isolate this matter M. Pasteur forced the aspirated air through a tube filled with gun-cotton, which is entirely soluble in ether, and this solution showed on the slide of a microscope minute bodies now known to be the germs or ova of these lower forms of the life. There is, then, no such thing as spontaneous generation, but only growth and reproduction from these invisible spores floating every-where in the atmosphere. Wherever dust is found

these microscopic germs are there also; and wherever dust settles, there these spores may, under favoring circumstances, reproduce themselves. The only way in which they can be entirely removed from the air is to filter it through many layers of cotton-wool, or to heat it sufficiently to destroy all these organisms. This requires a heat of at least 100 degrees C. (212 degrees F.), although, according to Tyndall's experiments, the same result may be at last obtained by inclosing air for a considerable length of time in a glass box whose walls are smeared with glycerine. A ray of electric light sent through the space within the box shows it at first full of the same floating motes that can be seen in the air of our living-rooms but little by little these subside and are caught and held by the sticky glycerine until at last the electric spark shows that the air is clear as crystal and absolutely moteless. The air upon the tops of high mountains is similarly free from organic germs, and hence unable to produce purefaction, for without germs no microbes and without microbes no putrefaction. It was on the mountain top of the Alps that Prof. Tyndall gave spontaneous generation its final quietus, by a series of experiments worthy of recital here, as the advocates of spontaneous generation have never yet met or disproved them. Prof. Tyndall took thin turnip slices, barely covered them with distilled water at a temperature of 120 degrees, and after allowing it to stand four or five hours poured off the liquid, filtered it, and thus obtained a clear infusion. This was sucked into sixty small, clean, empty flasks, with long necks, projecting sideways, by the process of alternately heating and cooling the flasks. Then the flasks were plunged into a trough filled with oil, and the contents made to boil. Finally, the neck of the flask was closed by heating the glass, and the flask "is lifted from the oil-bath sealed hermetically," that is, from the air.

"The flasks are then taken to the Alps, seven thousand feet above the sea. There six of them are found to be broken, and the infusion within is found to be muddy. Air has en-

tered through the broken necks, and hence this muddiness. Examined with a microscope the infusion is found full of organisms, some wabbling slowly, others shooting rapidly, across the microscopic field. They dart hither and thither like a rain of minute projectiles; they pirouette and spin so quickly round that the retention of the retinal impression transforms the little living rod into a whirling wheel."

These are the bacteria. Has this multitudinous life been spontaneously generated in these six flasks, or is it the progeny of living germs carried into the flasks by the entering air? If the former be true, how does it happen that the fifty-four uninjured flasks are destitute of all forms of life? Is it said that the air itself is the one thing needed to wake up the dormant infusion? He solved the problem after this fashion: Twenty-three of the flasks are taken to a hay-loft, and with a pair of steel pliers their sealed ends are snipped off. At once, of course, there is an inrush of air. Then twenty-seven are taken to a ledge overlooking the Aletsch glacier, about two hundred feet above the hay-loft, from which ledge the mountain falls almost precipitously to the north-east for about a thousand feet, with the following results, given in Tyndall's own words:

"A gentle wind blows toward us from the north-east—that is, across the crests and snowfields of the Oberland Mountains. We are, therefore, bathed by air which must have been for a good while out of practical contact with either animal or vegetable life. I stand carefully to leeward of the flasks, for no dust or particles from my clothes or body must be blown toward them. An assistant ignites the spirit-lamp, into the flame of which I plunge the pliers, thereby destroying all attached germs or organisms. Then I snip off the sealed end of the flask. Prior to every snipping the same process is gone through, no flask being opened without the previous cleansing of the pliers by the flame. In this way we charge our twenty-seven flasks with clean, vivifying mountain air.

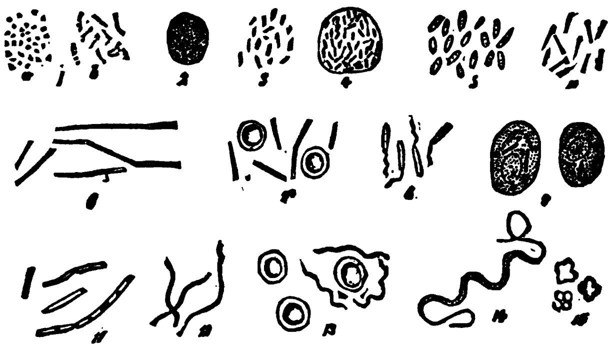
"Now note the result. In three days every one of the

twenty-three flasks opened in the hay-loft were invaded by organisms. After three weeks' exposure to precisely the same conditions not one of the twenty-seven flasks opened in the free air but is as clear as on the day it was brought from London.

"What is the conclusion? Is not the inference imperative that it is not the air of the loft, which is connected by a constantly open door with the general atmosphere, but something that is within the air that has produced the observed effects?"

This "something" is the microscopic spores or germs, already described by Pasteur, and which can be seen floating in every ray of sunlight let into a darkened room. These spores or germs are produced within microscopic plants or animals, from which they escape by a rupture of the parent cell wall, and, drying, form an object of such infinitesimal lightness that it can be carried hither and thither and everywhere by every breath of air. Any ordinary range of temperature does not affect them, but, as has been seen in Pasteur and Tyndall's experiments, they can be destroyed by a heat sufficient to bring glass to redness. Air thus treated is said to be sterilized, a term that is also applied to flasks and other instruments similarly treated to avoid mistakes in studying these minute forms of life. Spores under the microscope are bluish, opalescent bodies, which do not readily take up artificial coloring matter unless their membranes have been previously acted upon by acids or a great heat. The latter is sufficient, as has already been said, to destroy their vitality, but unless thus treated they preserve their power of growth on the average about three years, although Pasteur claims to have kept them vital for twenty-two years in hermetically sealed tubes. For the growth of microbes from these spores it is necessary only that they should fall into the proper soil. Putrid meat, beef-tea, or any vegetable or animal infusions form excellent culture-fluids, as they are called; that is, liquids well adapted for the rapid growth and multiplication of these spores. Latterly, solids have been more largely employed for this purpose, on account of the

difficulty of keeping fluids free from the spores of all but one kind of the lower forms of life, for each of these has its own particular spore, or seed, and these are very apt to be found together. All spores closely resemble each other, but, like germinal matter, they only produce after their own kind, as certainly as a duck's egg never hatches out any thing but a duck.



VARIOUS BACTERIAL FORMS.

1. Micrococcus septicus; *a*, scattered; *b*, in chains—torula. 2. Same in zoöglœa form. 3. Bacterium termo. 4. Same—zoöglœa. 5. Bact. lineola. 6. Bacillus subtilis. 7. Bacillus anthracis and blood-corpuscles. 8. Bacillus (from mouth) with cilium. 9. Bacillus lepræ. 10. Bacilli with spores. 11. Bacillus malariæ. 12. Vibrio serpens. 13. Spirochæte Obermeieri. 14. Spirillum volutans. 15. Sarcina. × 500. (Copied from Ziegler's path. Anatomie, Jena, 1882.)

The general name of bacteria (singular, bacterium) is applied popularly to all forms of life produced as just described. At first, they were known as animalculæ; later, as infusoria; at present, microbes (little lives) is their proper scientific name. By whatever name they may be called, they are essentially microscopic bits of protoplasmic matter, whose place in the scale of life has not been definitely settled. The Germans call them "spaltpilze," that is, split or divided fungi, and such they are in so far as they have no chlorophyl, or the green coloring matter found in plants proper. On the other hand, their growth is more like the algæ, or seaweeds, than the true fungi, but the algæ have chlorophyl, so it is impossible to group the microbes with them. Most

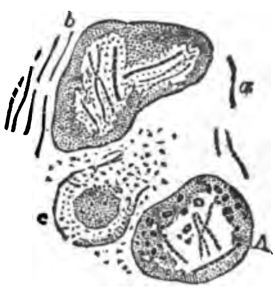
probably microbes form a group by themselves, resembling the plants in their mode of growth, but like animals absorbing oxygen and excreting carbon dioxide gas. Wherever they belong these microbes are infinitesimally small beings, without nuclei or cell walls, almost colorless and structureless. They have no blood-vessels or nerves. They seem to be simple protoplasmic or germinal matter with the same power of self-motion possessed by the white blood corpuscles. Some of them have minute paddles or tails, by which they propel themselves with wonderful rapidity through the fluids in which they live, but most of them undulate and oscillate to and fro without any visible means of propulsion.

So nearly colorless and structureless are the microbes that their study would be almost impossible without the aid of the coal-tar colors. The black refuse from the main of a gas-house is about as unlikely and unpromising an object as you will often meet with, to be of any real value to man. But chemistry is always bringing the unlikely to pass, for the study of a most unpromising subject often brings brilliant results. A common ant crushed on a bit of blue litmus leaves a red stain, and from that red stain came the discovery of chloroform. The red stain is due to formic acid, from formic acid came formyl, and from formyl came its terchloride, or chloroform, the best gift that ever came to suffering humanity. A little more than sixty years ago a chemist by the name of Unverdorben found a coloring matter in indigo, to which he gave the name aniline, from the Portuguese word for indigo. It was a discovery that attracted but very little attention, and was supposed to be of no practical use, as it was for the next thirty years.* About that time another investigating genius, named Perkins, found the same substance in the coal-tar just mentioned. Very little attention was paid to this discovery as well, until it was found that from aniline oil could be made a dye called alizarine, which could be made to take the place of madder. The discovery of alizarine has revolutionized the industry of dyeing. Hundreds of acres that were formerly given up to the

cultivation of the root from which madder was obtained are now utilized for the cultivation of wheat, or other foods. But it is not our purpose here to speak of all the changes that the aniline colors have wrought, but simply of their very great value in staining microscopic objects, especially these lower forms of life, which take from the aniline dyes a deeper tint than the surrounding tissues. In this way the microbes have been made distinct, and their study possible and exact.

It is not our purpose here to name all the forms and varieties of microbes that have been discovered up to the present time. The literature on the subject is already extensive, and the names chosen are so largely from the Greek that they are not adapted for general use. Take, for instance, the naming of the colonies of bacteria; for example,

1. Torula, in the form of a necklace. (Pages 224, 226.)
2. Leptothrix, made up of bacteria clustered end to end.
3. Mycoderma, immobile, composed of bacteria in sheets.
4. Zoozoea, being masses of bacteria, immobile, inclosed in a sort of jelly which holds them together. For all these the simpler names of necklace, chains, sheets, and jelly would have answered every purpose. Three of these names, however, have come into so general use that they require definition here, which can be greatly assisted by comparing these microbes to well-known objects. The first, except that it is infinitely smaller, closely resembles a billiard ball. This is the micrococcus. Next in order of frequence are the bacilli, so named from the Latin name for a rod, bacillus; for these resemble in shape an unsharpened lead-pencil, and are the most hardy of all the microbes. Lastly, we have the spirillæ, or those which resemble a corkscrew in shape. The varieties and subdivisions of these are almost endless, but their tech-



Bacilli and micrococci in tubercular deposit.

nical names do not particularly concern us, except, perhaps, their further division into aerobians, or those which require air for their growth, and the anaerobians, or those microbes which flourish without the presence of oxygen. And flourish they do amazingly, for the most wonderful thing in regard to these microbes is their wonderful power of multiplication. A generation of bacteria can be begotten in a single hour; or, in other words, a single bacterium may produce two in that time, and these again four in another hour; and if this rate of increase should continue for only three days, at the end of that time there would be 4,772,000,000,000, or 7,500 tons. Fortunately this cannot happen, for this fearful rate of multiplication is cut short by their inability to obtain proper food; for microbes, like all other living beings, must have food or die. Moreover, fortunately, by their growth they produce compounds, such as alcohol, which are destructive to coming generations, for otherwise the presence of a single bacterium would soon overwhelm us with a deluge of infusorial life compared to which the biblical deluge was but a trivial matter.

Microbes reproduce themselves in two way; snamely, by fission, or gemmation, and by the formation of spores. The first takes place wherever the exceedingly rapid growth occurs which has just been spoken of. This fission consists of a splitting of the animal into various segments, or buds, which soon dissolve partnership with their parent and set up housekeeping on their own account. As we have already seen, in the course of half an hour they themselves may suffer internal convulsions and split up, or send out segments which similarly divide until their supply of food is exhausted. For you must know that these microbes, like us of larger growth, have their likes and dislikes in the way of diet. One microbe's food is emphatically another microbe's poison, or at least his starvation, for some forms will grow and flourish in beef-tea, but absolutely refuse the daintiest raw potato; as is the case with the bacillus, which is supposed to produce consumption. The one that causes chicken

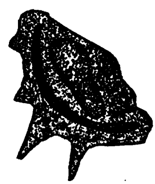
cholera is decidedly ghoulish in its tastes, for it likes best of all a broth made from the chicken which it has slain. The bacillus of cholera morbus is not at all dainty, for it will grow equally well in animal or vegetable broth, and the hay-tea bacillus is equally at home in old cheese.

In these latter days the scientists have become very Delmonicos in providing for the taste of the microbes; for instance, at Koch's laboratory they have a bill of fare set before them consisting of Pasteur's fluids, hay-soup, beef-tea, chicken-broth, putrid urine, milk, raw potatoes, old cheese, peptonized meat, and gelatinized blood. Surely it must be a dainty microbe that cannot find here something to its liking. But seriously, in Berlin and elsewhere, with almost infinite patience and painstaking precaution against error, these lower forms of life have been carefully studied, with results that have revolutionized our theories concerning fermentation, putrefaction, molds, parasites, and many forms of disease. It lies outside of our intention to attempt a review of all that the study of microbes has accomplished. But it has already repaid a thousand-fold in money all that the investigation has cost. In proof of this we have but to instance the results obtained in checking the vine and silk-worm diseases, which were devastating these industries in France. In 1853 the French silk crop amounted to something over 50,000,000 pounds. Little by little this gradually decreased until it reached only one fifth of this amount, owing to a strange mortality which occurred in the caterpillars which produced the cocoons. This disease was found by Pasteur to be due to infusorial life, and by carrying out the precautions suggested by him it was brought to a halt, until the silk crop of France has again reached the proportions of 1853. Neither have we space to speak of the results obtained in the treatment of chicken cholera, anthrax, sheep tag, or of the changes wrought in brewing, distilling, and bread-making, but in conclusion only of some of the possible relationships of these lower forms of life to our own bodies and their diseases.

Beale and his school claim that microbes have nothing at all to do with the production of disease, but are simply an accidental accompaniment. It certainly is true that some of these lower forms of life are perfectly harmless to a healthy body. In fact, there is good reason to believe that certain of them actually serve as scavengers in the intestinal canal, there feasting and gorging themselves, like the vultures of the East, on what would otherwise be dangerous and hurtful to us. So long as they keep within their bounds these organisms are helpful; but let them in any manner enter the blood and they produce poisonous effects. At least this is the present theory of many diseases, and it has been worked out with remarkable ingenuity and plausibility. In medicine, as elsewhere, the pendulum is too apt to swing from one extreme to the other, and just now there is an effort to explain almost every form of disease, from erysipelas to cholera, as originating from bacterial infection, and in many cases with apparent success. In the case of consumption, for instance, this has been done with so much care, and it explains so many features of the disease that have hitherto been inexplicable, that it may be taken as a fair instance of what is known as a bacterial disease. The infection in the case of consumption is supposed to be a straight rod-like body, discovered by Koch, of Berlin, and named by him *bacillus tuberculosis*. This rod-like body is so minute, and in color so closely resembles the tissues in which it is imbedded, that it is only by the most careful staining and manipulation that it can be recognized. So difficult is this that not a few good microscopists at first denied its existence entirely, claiming that Professor Koch had mistaken fat crystals and all sorts of other small objects for bacilli. But with wonderful patience Koch so verified his work that to-day even his most obstinate opponents admit that this microbe is found in consumptive tissues, and, so far as we now know, nowhere else. So generally is this admitted that, to the knowledge of the writer, a lady has been exiled from her home for a year and more solely on the evidence of a single bacillus in matter

that was coughed up. And wisely, too, if we admit this theory of consumption, for the presence of this bacillus in the sputum indicated that it had found a lodgement in the lungs, and, in the natural course of events, unless promptly exterminated, would grow and multiply until its unfortunate hostess should fall a victim to its ravages.

The origin of the disease as thus explained is that these bacilli, escaping from some other consumptive patient, become dried, and with other microscopic spores are carried hither and thither in the atmosphere until they find some suitable lodging-place. Probably they will not grow on the air passage of a perfectly healthy lung any more than thrush will in a perfectly healthy mouth. But let either parasite find a mucous membrane in the proper condition for its growth, it will fasten and multiply there each after its own fashion. The consumption bacillus is one of slow growth, so that it may be years in producing death, but it nevertheless slowly multiplies at the expense of the lung in which it is imbedded, until at last the person dies, not so much from the presence of the bacillus as from the products resulting from its growth. If for any reason the deposit is small, or the consumptive changes his residence to such a climate that the microbe, after a struggle for existence, perishes, recovery may take place, as not unfrequently happens. Similar causes are given for cholera, malaria, hydrophobia, erysipelas, yellow and typhoid and all of the contagious fevers, with much plausibility, but as yet without convincing proof. In the blood of measles and scarlet fever it is claimed that rod-like bacilli can be found, and that the inoculation of these conveys the disease from one to another. The degree of virulence of the disease is explained by the behavior of the white corpuscles toward the invading bacilli. The former endeavor to bodily swallow the invading microbes, if we can trust the description of the scientist who figured the act as given on this page. Given sufficient white corpuscles to



Leucocytes devouring bacillus.

devour the bacilli, there will be but slight fever; given more bacilli, a severer attack. At least this is the theory of the adherents of the germ-theory of disease, but in fairness those of Dr. Beale ought also to be given. In writing on the subject, he says:

"Old epithelial cells, like other old and formed tissue, or other dead, organic, animal, or vegetable matter, very soon become invaded by low vegetable organisms, which grow at their expense and live upon their substance. Not only in the substance of these cells, but upon their surface, the fungus germs are found, and frequently project from them, forming little collections which may be detached from time to time.

"Among the hair-like epithelial processes projecting from the free extremities of the filiform papillæ are often found masses which have a granular appearance under low magnifying powers; but when examined under objective magnifying more than three hundred diameters, will be found to consist of millions of spherical and oval fungi, or micrococci, grouped together. . . . The first question you will ask will probably be this: 'Do these germ-particles perform any distinct office, or function, in connection with the solution of food or digestion, or do they merely live and grow upon the old epithelial cells and the debris of the food, which must needs undergo change in such a solution, and at the temperature of the inside of the mouth?' We find such bodies in animals as well as man, and though they are found in greatest number in certain derangements, multitudes are constantly present in the most healthy individuals.

"Wherever organic matter is undergoing change and disintegration, in an organism or outside of it, at the temperature of man's body or some degree lower or higher than this, and in some cases at a much lower temperature, such organisms exist in a countless multitude, and grow and multiply at the expense of the disintegrating organic matter. At this time of the year (October) there is not a leaf in which you will not find millions of low vegetable organisms in various stages

of development and growth. Fungus germs exist in the air at every part of the earth's surface at all times. Though by no means constantly present in precisely the same amount, some are always to be detected in appreciable numbers if the air is properly examined. Many coming into contact with the moist surface of the leaf about to decay find there a surface favorable for their development. The spores germinate, and from the surface of the tissues of the plant the growth easily makes its way into the substance. . . . As the leaf grows old, substances are formed which are easily appropriated by the fungi. The germs of these are present, and are ready to develop just at the time when the appropriate pabulum is formed. The fungus does not spring from the leaf, neither is the leaf caused to grow old by the fungus, and its deterioration begins before the growth of the fungus commences. . . . In the case of the higher animals and man, at least, in many instances in which low organisms are associated with morbid processes, these last are neither the cause of disease nor are they produced by it. Germs, being present, will grow and multiply wherever the surrounding conditions become favorable. If these remain for a considerable time unfavorable, the germs, if present, remain quiescent and may at last die.

"As it is with regard to deteriorating vegetable tissues, so it is with regard to decaying animal tissue. Whether the body be in a state of health or disease, wherever tissue is about to undergo chemical change, wherever decomposition is taking place, or is approaching, the conditions may be favorable for the growth and multiplication of certain low vegetable organisms, the germs of which are present. Long before the changes akin to deterioration and decay are ordinarily supposed to commence, even from the very earliest period of construction and growth, fungus germs are ever present, ready to grow and multiply should death and disintegration of a living particle occur. No wonder, then, that we find so many low organisms growing in connection with the old epithelium of the mouth and of the tongue, of the

esophagus and other parts. Under certain circumstances, the fungi grow and multiply to a vast extent lower down the alimentary canal. Multitudes, as I have said, pass down the alimentary canal every time we swallow food or fluid. Such ordinary bacteria and their germs do us no harm whatever. But please do not infer from what I have said that the putrid fluids loaded with bacteria are innocuous, or to be recommended. Organic matter in a state of putrefactive decomposition, when introduced into the alimentary canal, gives rise to pathological phenomena irrespective of the bacteria it may contain. . . .

"Whether it is some special bacterium which causes the results consequent upon the introduction of specific poison into the organism, or whether the active particles are of a totally different nature, altogether independent of bacteria and allied organisms, is still an open question. Some evidence has been recently adduced in favor of the hypothesis that there are bacteria and bacteria—that the real contagious bacterium is an organism altogether apart from the harmless bodies so intimately connected with every part of every one of us. Further, it has been surmised that the horrible death-carrying bacteria of various orders have been somehow derived from the harmless form by pathological transformations, or developed in the course of evolutional struggles proceeding through the ages, or that they are the product of a constantly altering environment. But many new facts must be discovered and much must be learned concerning special bacterial phenomena before the problem can be solved."

And to solve this problem is being waged just now most acrimoniously what may hereafter be known as the battle of the microbes. Whatever may be its result, we shall be forced to confess with St. Augustine that the power of God is shown most in the little things. Whether these microbes prove eventually to be our deadliest foes, or nature's invisible scavengers, who injure us only when we force them to work where they ought not, they have already taught us much of practical value. A clean wound is not one which has been

merely washed, but one protected from the presence of these microbes. Modern surgery in this way obtains results undreamed of by our fathers, for their best efforts were opposed by invisible foes whose existence they never suspected. The blessings of clean streets, quarantine, and increasing years of life are largely the results of the patient study in a Parisian laboratory of the difference between tartaric and paratartaric acids—a subject that the so-called practical man would have sneered at as of not the slightest earthly importance.

As yet we know but in part, but from this partial knowledge, if we are wise, we have learned sufficient to convince us that this house in which we live is not a mere joining together of chance atoms. On the contrary, the greatest care has been taken in its construction and in its protection from injury, wherein we find the explanation of the mystery of pain. No truer or more beautiful words have ever been written on this subject than those of an unknown writer in *Temple Bar* some years ago:

"The power which rules the universe—this great, tender power—uses pain as a signal of danger. Just, generous, beautiful Nature never strikes a foul blow; never attacks us behind our backs; never digs pit-falls or lays ambuscades; never wears a smile upon her face when there is vengeance in her heart. Patiently she teaches us her laws, plainly she writes her warnings, tenderly she graduates their force. Long before the fierce red danger-light of pain is flashed, she pleads with us, as though for her own good's sake, not ours, to be merciful to ourselves and to teach each other. She makes the overworked brain to wander from the subject of its labors.* She turns the over-indulged body against the delights of yesterday. These are her caution signals, 'Go slow.' She stands in the filthy courts and alleys that we pass daily and beckons us to enter and realize with our senses what we allow to exist in the midst of the culture of which we brag. And what do we do for ourselves? We ply whip and spur on the jaded brain as though it were a jibbing horse

—force it back into the road which leads to madness, and go on full gallop.

"We drug the rebellious body with stimulants; we hide the signal and think we have escaped the danger, and are very festive before night. We turn aside, as the Pharisee did of old, and pass by on the other side with our handkerchief to our nose. At last, having broken Nature's laws and disregarded her warnings, forth she comes—drums beating, colors flyings—right in front, to punish us.

"Then we go down on our knees and whimper about it having pleased God Almighty to send this affliction upon us, and we pray him to work a miracle in order to reverse the natural consequences of our disobedience, or save us from the trouble of doing our duty."

In other words, we thrust our fingers into the fire and then pray that we may not be hurt, for that in reality is what the so-called metaphysical and faith cures amount to. They are in the same line of argument as Ingersoll's sneering blasphemy: "Why is not good health catching, as well as disease?"

The body, like all else of the Creator's work, was originally "very good," and if our bodies at present are not so, then either we or our parents have damaged them. Why we should be allowed to do this we shall probably never be able to explain until we cease to see in part, and that which is earthly is done away with; but recognizing the fact, which is beyond dispute, what are we going to do about it? And we ask the question reverently, and as one of importance, for our bodily ills, trivial as they may seem to others, are very important factors in our lives for good or ill. Paul's thorn in the flesh did as much to make him the invincible apostle that he was as did Byron's club-foot to make him a gloomy, misanthropic cynic. Strangest of all, in these latter days we find good men and women who claim that Paul had no business with thorns in the flesh. No Christian doubts the power of God to perform miraculous cures if it seem best to him, but as yet the evidence is not sufficient to warrant

other conclusions than that the laws of Nature are allowed to take their course with the body just as they do with other material objects. No one dreams of faith being necessary to heal the galled back of an overworked farm-horse. Natural laws have to be utilized for the recovery of disease for the same reasons that their violation brings disease. Sickness, as is well said by Dr. Hunt, is "providential penalty" for violated law, and it is gross disrespect to the Judge of all to expect that these providential penalties should be annulled by the request of one of his petit jury. Trophimus had to be left sick at Miletum notwithstanding the prayers of Paul and himself, or the then Christian Church. And yet in these latter days there has grown up the strange delusion that with an illogical, hysterical girl or an ignorant backwoodsman has been placed power such as was denied Paul.

No fairer putting of the whole case of faith-cures can be made than will be found in the following inductions taken from an article by Rev. Dr. James M. Buckley in the *Century Magazine.*

"1. That subjective mental states, as concentration of the attention upon a part with or without belief, can produce effects either of the nature of disease or cure.

"2. Active incredulity in persons not acquainted with these laws, but willing to be experimented upon, is often more favorable to sudden effects than mere stupid, acquiescent credulity. The first thing the incredulous, hard-headed man, who believes that 'there is nothing in it,' sees that he cannot fathom may lead him to succumb instantly and entirely to the dominant idea.

"3. That concentrated attention, with faith, can produce very great effects; may operate powerfully in acute diseases, with instantaneous rapidity upon nervous diseases, or upon any disease capable of being modified by direct action through the nervous or circulatory system.

"4. That cures can be wrought upon diseases of accumulation, such as dropsy and tumors of various kinds, with great rapidity, where the increased action of the various

excretory functions can eliminate the accumulations from the system.

"5. That rheumatism, sciatica, gout, neuralgia, contraction of the joints, and certain inflammatory conditions, may disappear under similar mental states suddenly, so as to admit of helpful exercise, which exercise by its effect upon the circulation, and through it upon the nutrition of diseased parts, may produce a permanent cure.

"6. That the 'mind-cure,' apart from the absurd philosophy of the different sects into which it is already divided, and its repudiation of all medicine, has a basis in the laws of nature. The pretense of mystery, however, is either honest ignorance or consummate quackery.

"7. That all are unable to dispense with surgery where the case is in the slightest degree complex and mechanical adjustments are necessary; also that they cannot restore a limb, or eye, or finger, or even a tooth which has been lost. But in certain displacements of internal organs, the consequence of nervous debility, which are sometimes aided by surgery, they all sometimes succeed by developing latent energy through mental stimulus.

"8. All that they really accomplish can be paralleled without assuming any supernatural cause, and a formula can be constructed out of the elements of the human mind which will give as high average results as their prayers or anointings.

"Is there then no warrant in the New Testament for the ordinary Christian to pray for the sick, and is there no utility in such prayers? The operation of the providence of God upon the minds of men and upon their bodies, through the order of cause and effect which he has established, has not come under review. The New Testament affirms that 'All things work together for good to them that love God.' It also teaches that the Spirit of God has constant access to the minds of men, and sets forth an all-inclusive doctrine of Providence, without which not even a sparrow falls. It does not say that prayer will always secure the recovery of the

sick, for it gives the case of Paul, who had a thorn in the flesh, and who said, 'I besought the Lord thrice that this thing should depart from me,' but received, 'My grace is sufficient for thee.'

"None can demonstrate that God cannot work through second causes, bringing about results which, when they come, appear to be entirely natural, but which would not have come except through special providence or in answer to prayer. The New Testament declares that he does so interfere 'according to his will.'

"It was not his will in the case of Paul, and he did not interfere, but gave spiritual blessings instead. No one can tell when he will interfere. But prayer for the sick is one of the most consoling privileges, and it would be a strange omission if we were not entitled to pray for comfort, for spiritual help, for such graces as will render continued chastening unnecessary, and for recovery, when the thing prayed for is in harmony with the will of God. The belief that when the prayer is in accordance with the mind of God 'the prayer of faith shall save the sick, and the Lord shall raise him up,' is supported by many explicit promises. But as all who die must die from disease, old age, accident, or intentional violence, every person must at some time be in a state when prayer cannot prolong his life.

"When we or others are sick the Christian doctrine is that we are to use the best means at command, and to pray, 'Father, if it be possible, let this cup pass from me; nevertheless, not my will but thine be done.' The prayer may be answered by its effect upon the mind of the patient; by directing the physician, the nurse, or the friends to the use of such means as may hasten recovery; or, for aught we know, by a direct effect produced upon the physical system, behind the visible system of causes and effects, but reaching the patient through them; then, if the patient recovers, it will seem as though he recovered naturally, though it may be in an unusual manner. The Christian in his personal religious experience may believe that his prayer was the element that

induced God to interfere and prolong life. Assuming that there is a God who made and loves men, none can show his faith irrational or unscriptural; but such testimony can be of no value to demonstrate to others a fact in the plane of science. When the time comes that the Christian is to die, he must then rest, even while praying for life, upon the promise, 'My grace is sufficient for thee.'

"The faith-healers represent God as interfering constantly, not by cause and effect in the order of nature, but effecting the result directly. Their want of superiority to those who are not Christians, but who use either false pretenses or natural laws, and their inferiority to Christ and the apostles, condemn their pretensions. Nor does it avail them to say, 'Christ would not come down from the cross when taunted by unbelievers.' They might, perhaps, with propriety refuse a test for the test's sake, though Elijah forced one. But in a close observation of their works the radical difference between them and those who they say have no divine help should be manifest. Some of them affirm that the Mormons, Newton, and others, do their mighty works by the aid of devils. If so, since casting out devils was a miracle-working power of a very low grade, it is wonderful that none of these persons have been able to cast out the devils from any of the great number who are working in this way, and thus demonstrate their superiority as the apostles vindicated their claims against Simon the sorcerer and others.

"Faith-cure, technically so called, as now held by many Protestants, is a pitiable superstition, dangerous in its final effects.

"It may be asked, What harm can result from allowing persons to believe in 'faith-healing?' Very great, indeed. Its tendency is to produce an effeminate type of character which shrinks from any pain, and to concentrate attention upon self and its sensations. It sets up false grounds for determining whether a person is or is not in favor of God. It opens the door to every superstition, such as attaching importance to dreams, signs, opening the Bible at random, expecting the

Lord to make it open so that they can gather his will from the first passage they see, 'impression,' 'assurances,' etc. Practically it gives great support to other delusions which claim a supernatural element. It greatly injures Christianity by subjecting it to a test which it cannot endure. It directs attention from the moral and spiritual transformation which Christianity professes to work—a transformation which, wherever made, manifests its divinity, so that none who behold it need any other proof that it is of God. It destroys the ascendency of reason in the soul, and thus like similar delusions it is self-perpetuating, and its natural, and in some minds its irresistible, tendency is to mental derangement.

"Little hope exists of freeing those already entangled, but it is highly important to prevent others from falling into so plausible and luxurious a snare, and to show that Christianity is not to be held responsible for aberrations of the imagination which belong exclusively to no party, creed, race, clime, or age."

PART II.—APPENDIX.

PRACTICAL HINTS FOR THE DEVELOPMENT OF THE BODY.

First wealth is health, says Emerson; but health can no more be kept than wealth without care for its preservation. The more so in the case of health, for the reason that, as we grow older, outside cares distract us, and the body is neglected until damaged beyond repair. Few bodies, like few houses, are absolutely perfect in all their parts, but neither houses nor bodies should be neglected; especially in the case of the body, since we are absolutely sure that it is the only one which will be given us for our use here, and when once dilapidated we must bear the consequences. Exercise is Nature's method of keeping this house of ours in good order, for if the ablest bodied man sits down, like an Indian fakir, to do absolutely nothing, his joints, like the East Indian devotee's, will become stiff and useless. And in direct measure as we defraud ourselves of necessary exercise shall we find ourselves crippled thereby. Exercise will do much more than keep us in good health, for when properly used it will repair inherited and acquired defects, and much of what is hereafter detailed is designed for that purpose—that is, for body-building, as it is well called by Dr. Hunt. Wherever, says he, a particular organ shows a lack of development or vigor this is required; but "to over-develop a set of muscles, as those of the arm for great lifting, does not always include a strengthening of the whole frame-work. It is body-building we need; we are to seek such vital capacity, such adjustment of all the parts, as will best sustain the whole. Many a person loses health because there is a defect in one

vital part even when all the rest of the system is in good condition. The strength of a chain is to be estimated by that of its weakest link, and this is too often the case as to the strength of the body. Where we cannot fully repair, or bring a person fully up to a higher standard of health, we can study the type of the individual, and bring him up to a higher standard of comfort and vigor. We use the resources we have to acquire more. All do not begin with the same capital of health, or even acquire it, but they can, at least, learn what their capital is, and its ability of preservation or increase, and live accordingly.

"Very active exercise should not be taken just after a full meal. The reason of this is that the supply of vital force is generally diminished just before a needed meal, and that digestion itself, in its first processes, has not yet refurnished the system. Observation shows us that most animals incline to quiet immediately after eating. Active exercise before breakfast is not generally beneficial. No doubt it may be advantageous to such as have large vital force; but experiment shows that it is better, after so long a fast, to take some nourishment before exercise. The forms of exercise most to be relied upon by those in good health, and who are not seeking to remedy any special disability, are such as bring into play the most of the voluntary muscles used for a change of place. Walking is a specimen of natural exercise, and, like some others, has this advantage, that it also gives us a change of air and change of scene. On the other hand, stair-climbing is a form of unnatural exercise, which, if frequent and long-continued, is an injury to many, and especially to young girls. The most uniform rule as to the extent and degree of exercise is that it shall continue until there is a feeling of glow or warmth of surface, or a slight perspiration. Exercise may be carried beyond this without harm, as is often necessary in work, and of advantage during the process of growth. But the value of exercise, as such, is generally reached when there is glow and slight perspiration. A feeling of fatigue is always an indication

of a needed partial or continued rest, or a change as to the mode of exercise."

Full bodily development can only be secured by means of the systematic exercise of the parts of the body found wanting. Measurements for these may be found at the close of the present chapter, and where deficiencies are found the hints herein contained, arranged from Blaikie's *How to Get Strong*, and Anderson's *Physical Training*, will prove helpful.

DAILY EXERCISE FOR A BUSINESS MAN.

Let him daily devote himself two or three minutes to the striking bag. Facing it squarely, with head back and chest well out, he should strike it a succession of vigorous blows, with left and right fists alternately, until he has done a hundred in all. If he has hit hard and with spirit he is puffing freely now, his lungs are fully expanded, his legs have a deal of springing about to do, and his arms and chest have been busiest of all.

If, once in mid-morning and again in mid-afternoon, the man, right in his store or office, will exercise for two or three minutes with dumb-bells, not weighing more than one and a half to two pounds each, he will find the rest and change most refreshing. But in any case, whether he does or not, every man in this country whose life is indoors ought so to divide his time that, come what may, he will make sure of his hour out-of-doors in the late afternoon, when the day's work is nearly or quite done. If he must get up earlier, or get to his work earlier, or work faster while he does work, no matter.

TO BROADEN AND DEEPEN THE CHEST.

Any thing which causes one to frequently fill his lungs to their utmost capacity, and then hold them full as long as he can, tends directly to separate the ribs, stretch the intercostal muscles, and so expand the chest.

Holding the head and neck back of the vertical, say six inches, with the face pointing to the ceiling, and then work-

ing with the dumb-bells at arms' length, carrying them backward, is excellent practice for the upper chest, tending to raise the depressed collar-bones and the whole upper ribs, and to make a person hitherto flat-chested now shapely and full; while the benefit to the lungs, perhaps formerly weak, would be hard to overestimate, especially in threatening phthisis.

Steady and protracted running is a great auxiliary in enlarging the lung-room; so is plenty of sparring; so is the practice of drawing air slowly in at the nostrils until every air-cell of the lungs is absolutely full, and then holding it long, and then expelling it slowly, four to eight times per minute.

TO ENLARGE AND STRENGTHEN THE FRONT OF THE CHEST.

All exercises designed for the biceps tell also on the pectoral muscles, for the two work so intimately together that he who has a large biceps is practically sure to have the adjoining pectoral muscles correspondingly large.

But the pectoral muscles are affected by other exercise than that of the biceps. Whenever the hands push hard against any thing, and so call the triceps muscles into action, these muscles at once combine with them. In the more severe work of the triceps, such as the dips, the strain across these chest muscles is very great, for they are then a very important factor in helping to hold up the weight of the whole body.

Working with the dumb-bells when the arms are extended at right angles with the body, like a cross, and raising them up and down for a foot or so, is one of the best things for the upper edge of the pectorals, or that part next to the collar bone.

TO STRENGTHEN AND DEVELOP THE HAND.

An admirable exercise in this direction is, when practicing pushing up from the floor to develop the triceps, to only touch the floor with the ends of the fingers and thumbs, never letting the palm of the hand touch it at all. This will soon help to rectify many a hand now rather cramped and con-

tracted, besides bringing new strength and shape to the fingers.

To make any particular finger strong, attach a strap to the bar (page 263) and placing that finger in the strap begin with raising a small weight from the floor until you have drawn your hand down to your chin; then from day to day gradually increase both the weight and number, until before a great while you may find that you can raise an equivalent of your own weight.

Just where the thumb joins the palm, and between it and the forefinger, on the back of the hand is a muscle which, at first usually small, can be developed and enlarged by any exercise which necessitates pinching the ends of the thumb and forefinger together, such as carrying a plate or other thin but heavy substance between the finger and thumb.

For improving the ordinary grip of the hand, simply taking a rubber ball in it, or a wad of any elastic material, or even of paper, and repeatedly squeezing it, will soon tell. Even simpler is it to just practice opening and shutting the hand firmly many times.

EXERCISES FOR THE TRICEPS MUSCLES.

Push with the hands against almost any heavy or solid thing you want to. If these muscles are small and weak, push the dumb-bells up over your head as much as you can daily, till a month's work has given them a start. For two or three minutes each day during that month stand facing the wall, and about two feet from it. Now fall against it, or rather, put your hands on it, about three feet apart and as high as your ears, and let your body drop in toward the wall till your chest nearly touches it, your face being held up and back. Then push sharply back till your body is erect again, and continue the movement.

Place the hands on the floor, hold the body out at full length and rigid, or as nearly so as you can, and push, raising the body till the elbows are straight as possible, and then raise on stiff elbows again, and so on. If this is not hard

enough work for the ambitious aspirant for stout triceps, he can vary it by clapping his hands between the dips, just as his face is farthest from the floor; though in such case it is sometimes well to have a nose accustomed to facing difficulties.

Place two stout chairs back to back, and then draw them about eighteen or twenty inches apart, and, placing one hand on each, holding the arms straight, lift the feet off the floor. Now lower till the chin is level with the hands, or nearly so, and then rise till the arms are straight, and then dip again, and so on, the knees and feet, of course, never resting on any thing.

FOREARM WORK.

Any thing which necessitates shutting the hand, or keeping it wholly or partly shut, such as holding any thing heavy in it, driving, chopping, fencing, single-stick, pulling one's self up with one hand or both, batting, lacrosse, polo; twisting the dumb-bells around when at arm's length, or a chair, or cane, or foil, or sword, or broom-handle, if the dumb-bells are not convenient; carrying a weight in the hand; using any of the heavier mechanical hand-tools—all these, and more of their sort, will enlarge and strengthen the forearm, and will do much for the hand also.

TO OBTAIN A GOOD BICEPS.

Starting with the dumb-bells down at the sides, as usual, raise them slowly and steadily upward in front until they nearly touch the shoulder—technically, "curl" them—holding the head up, the neck rigidly erect, and the chest expanded to its very utmost. Now lower the bells slowly to the sides again, and repeat, and so continue.

If no dumb-bell or other convenient weight is at hand place one hand in the other and bear down hard with the upper hand, holding the chest stubbornly out. Lift away with the lower hand, and when it reaches the shoulder lower it slowly to the side, and then raise again, and so continue.

Fasten a stout hook in a beam overhead and hang a pulley to it. Run a rope through this, at one end of which you can attach weights and tie the other to the middle of a thick cane or other bar, taking care to have the rope of such length in all that when the weight is on the floor the bar is about a foot above your head. Begin with, say, at first a weight of not over one tenth of your own weight. Grasping the stick with both hands, with their palms toward you, draw it downward until level with your chin, then let it go back; repeat, and continue till you begin to tire. If the weight seems too light attach another. After a few days with these fasten on a basket or coal-hod, and increase the load until, say at the month's end, it weighs over half of what you weigh.

If, on the other hand, one has these muscles already strong, and can with ease pull himself up six or eight times, he will find this stick and weight an excellent affair for training the biceps of one arm, until it gets strong enough to pull him up without the other arm at all.

Mount a ladder or a rope hand over hand; lift any weight in front of you, whether a feather or a barrel of sugar; pick up any thing from the floor; hold weights out in front, or at your side, at arms'-length; pull downward on a rope, as in hauling up a sail; hammer—in short, do any thing which bends the elbow and draws the hand in toward the shoulder, thus taxing the biceps muscle; and if the work is vigorous and persisted in, this muscle will erelong become strong and well shaped.

TO BRING UP THE MUSCLES ON THE FRONT AND SIDE OF THE SHOULDER.

For these muscles holding out weights at arms'-length, either at the side or in front, will be found just what is wanted, the arms being horizontal, or the hands being held rather higher than that, the elbows remaining unbent. Holding the mere weight of the hands, as in boxing, but keeping at it a while, keeps these muscles well occupied ; while the

sword, or foil, or single-stick, freely plied, or the ax or bat, tell directly here.

FILLING OUT THE SHOULDERS AND UPPER BACK.

Stand erect again with the chin up and chest high (in all the exercises stand erect where it is possible), and have the dumb-bells in the hands, hanging easily at the sides.

Now carry them slowly backward and upward, keeping the arms straight at the elbows, and parallel until the hands are about as high as they can well go. Hold them there a moment, then drop them slowly to the sides. Do it again, and keep on until you begin to feel like stopping.

Laying one dumb-bell down, now repeat the above exercise with the remaining one, say in the right hand, this time placing the left hand on the back just under the right arm, or on the inner portion of the triceps or upper muscle of the right arm. These muscles will be found vigorously at work, and hardening more and more the higher the bell is carried or the longer it is held up.

DEVELOPMENT ABOVE THE WAIST.

With a pair of dumb-bells, at first weighing not over one thirtieth of the weight of the person using them, and gradually, as the strength increases, substituting larger ones, until they weigh, say, one-tenth of the person's weight, there is scarcely a muscle above the belt which cannot, by steady and systematic work of never over one half hour daily, be rounded and strengthened up to what it ought to be in a thoroughly developed, strong, and efficient person of its owner's sex, size, and age, if long enough continued.

TO ENLARGE AND GIVE POWER TO THE LOINS.

All stooping over when lifting is done, as with a spade, or fork, or bar, whether the knees are held straight or bent, or lifting any weight directly in the hands, horizontal pulling, on a pulley-weight, rope, or oar—in short, nearly every sort

of work where the back is actively employed, keeps these muscles thoroughly active. You cannot bend over without using them.

COUNTERWORK FOR THE ABDOMINAL MUSCLES.

Stand erect. Now gradually draw the head and shoulders backward until as far past the vertical as possible. Return slowly to erect position.

All work such as swinging clubs, or an axe or sledge; putting up dumb-bells, especially when both hands go up together; swinging by the hands from rope or bar, or pulling the body up until the chin touches the hands; standing with back to pulley-weights, and taking the handles in the hands, and, starting with them high over the head, then pushing the hands far out forward; standing two or more feet from the wall, and, placing the hands side by side against it, about as high up as the shoulders, then throwing the chest as far forward as possible—these all do excellent service in bringing to these important muscles the length and elasticity they ought to have, and so contributing materially to the erect carriage of the body. All kinds of pushing with the hands, such as one does in putting them against any heavy substance and trying to push it before him, striking out in boxing, in fencing, or single-stick, with dumb-bells, or in swimming, are capital; while the drawing of the head back swiftly, as in boxing, to avoid a blow, can hardly be surpassed as an aid in this direction.

THE ABDOMINAL MUSCLES.

Lie flat on the back, as, for instance, just on awaking. Taking first a deep full breath, draw the feet upward, keeping the knees unbent, until the legs are vertical. Lower them slowly till horizontal, then raise again and continue. It will not take many minutes, or seconds, to bring these muscles enough work for one morning.

Or, this time keeping the legs down, and first filling the chest, now draw the body up until you are sitting erect.

Then draw slowly back, and repeat. This will be likely to take even less time than did the other, but it will tell tremendously on these muscles.

TO DEVELOP THE LEG BELOW THE KNEE.

The main part of the leg, below the knee, for instance, is composed of muscles which raise the heel. Stand erect, with the head high, chest out, and shoulders down, keeping the knees all the time well sprung back, having the feet about three inches apart, with the toes turned slightly outward. Now slowly raise the heels until they are high off the floor, and the whole weight rests on the soles and toes. Now drop slowly down. Then repeat. Next place the hand on the muscles of the calf, and, while at first not firm, feel them harden as you rise, and all doubt as to whether the exercise in question uses these muscles will speedily vanish. Continue this exercise at the same rate, keeping at it until you have risen fifty times.

There remains one other prominent muscle below the knee, that in front, running down along the outer side of the shinbone. Fast walking when one is unused to it, especially when the knees are held pretty straight, will work this muscle so vigorously as to make it sore. But a plain, safe, and simple exercise for it, yet one which, if protracted, will soon swell it into notice, and give it unwonted strength and beauty, is effected by stooping down as low as possible, the feet being but a few inches apart, and the heels never being allowed to rise even a quarter of an inch off the floor. Lift the heels, and this muscle is at once relieved.

Laying any weight on the foot, and lifting it clear from the ground, will also call on this muscle. Simply standing on one foot, first holding the other clear of the floor, and then drawing it up as near as possible to the front of its own ankle, and then opening it as wide as you can, will be found a safe and reasonably effective way of bringing forward this

small but useful muscle; while walking on the heels, with the toes drawn up high, is simpler yet.

WORK FOR THE FRONT OF THE THIGH.

Scarcely any muscles are more easily brought into action than these of the upper or front thigh. Stand erect, with head and chest high, and the feet about six inches apart. Now, bend the knees a little, say until the head has dropped vertically six inches. Then rise to the perpendicular again. This movement is very much akin to that in dancing, the latter being the harder of the two, because the weight is first on one foot, and then on the other, while in the former it is always on both.

A more severe tax yet is had by holding one foot far out, either in front or back, and then stooping down wholly on the other foot. Few can do this many times, and most persons cannot do this at all.

Jumping itself, either high or flat, is admirable for the thighs. Maclaren says that hardly any work will quicker bring up the whole legs; but this will probably prove true where a large number of moderate jumps are taken daily than where a few extreme efforts are made.

Both fast walking and running bring vigorous action to these muscles; slow walking does little for them, hence the number of weak, undeveloped thighs among men who do little or no quick foot-work.

Hopping, which is so good for the calves, is hardly less so for these muscles, and is one of the best possible movements to develop them in the shortest time.

A more moderate exercise than the running, though not always so available, is walking up hill. This, besides, as already mentioned, doing so much for the calves, tells directly and markedly on the thighs as well. Skating makes a pleasant substitute for walking during a part of the colder months, and, when much distance is covered daily, brings, strong shapely thighs.

All lifting of heavy objects from the ground tells heavily

on these muscles, but occasional heavy lifting tends rather to harden than to rapidly increase its size, protracted effort at lighter but good-sized weights doing the latter to better advantage.

Brisk horseback-riding keeps these muscles very actively employed. Every sort of work which calls for frequent stooping down does the same.

TO ENLARGE THE UNDER THIGH.

The muscles of the under thigh do not get nearly so much to do as those in front, in many persons seeming not to exist at all. The exercise already recommended, of pressing the sole of the foot hard on the ground just as it leaves it, is scarcely more beneficial to the muscles of the calf than to these; likewise walking up hill. Fastening a weight of any sort, a dumb-bell or flat-iron, to the ankle, say with strap or towel, and raising the foot as high up backward and outward as possible, and repeating until tired; putting the foot in the handle of a pulling-weight, and frequently drawing it far down; or, standing with back to the wall, and placing the heel against the base-board of the room, or any solid vertical surface, and pressing hard many times—these all tell on the hidden under-muscle.

TO STRENGTHEN THE SIDES OF THE WAIST.

Notice a man weak just here, and see his body sway a little from side to side as he walks, seeming to give at the waist. Were such a one to practice daily hopping straight ahead on one foot, and then on the other, until he could by-and-by cover half a mile without fatigue, he would find his swaying propensity fast disappearing; and if he has been troubled with a feeble or unshapely waist, that will also have gradually changed, until at the end it has become firm and well-set.

Take the long balancing pole of the tight-rope walker and try to walk a rope a while, or try the more simple expedient of walking on the railroad rail, and these muscles are at once

uncommonly busy. Notice the professional tight-rope man and see how strong he is here. His profession has compelled the continued use of these muscles.

DAILY EXERCISE FOR WOMEN.

And what should the girls and women do each day? With one-pound wooden dumb-bells at first, let them, before breakfast, go through with the exercises already given to develop the chest (page 259). After six weeks or two months they can increase the number gradually, and if this does not bring the desired increase in size and strength of arm, chest, and back, they can try dumb-bells weighing four or five pounds each.

Out of doors, either in the latter part of the morning or afternoon, let them, in broad, easy shoes, walk for one hour, not at any listless two-mile pace, but at first as fast as they comfortably can, and then gradually increase the pace. In a fortnight or more they can make sure of three miles and a half at least, if not of four miles within the hour, and that without great fatigue.

Girls should also learn to run. Few of them are either easy or graceful runners; but it is an accomplishment quickly learned; and begun at a short distance and at a slow jog and continued until the girl thinks nothing of running a mile in seven minutes, and that without once touching a heel to the ground, it will do more than almost any other known exercise to make her graceful and easy on her feet, and also to enlarge and strengthen her lungs.

If besides these things the girl or woman will determine that, as much as possible of the time each day in which she is sitting down, she will sit with head and neck up, trunk erect, and with her shoulders low, and that whenever she stands or walks she will at all times be upright, she will shortly find that she is getting to be far straighter than she was, that she has a larger, finer chest than formerly, and that she can more easily fill her lungs.

ANTHROPOMETRY.

The question naturally arises, What should be considered the normal development for a healthy adult. Up to fourteen, girls as a rule are slightly heavier and taller than boys, but after that time the average boy is larger than the girl of the same age. As a standard of comparison, and for learning what parts are deficient in one desiring symmetrical development, we add the following table by the courtesy of the Narragansett Chest Weight Company:

A TABLE

SHOWING THE PROPER WEIGHT, HEIGHT, AND MEASUREMENT OF A FULLY DEVELOPED ADULT.

Height.	Weight.	Neck.	Chest.	Waist.	Biceps.	Forearm.	Thighs.	Calves.
5 ft.	103–107	11⅛	32–33	29	Same measurement as for neck.	8⅞	15	Same measurement as for neck.
5 " 1 in.	107–111	11½	33–34	29½		9¼	16	
5 " 2 "	111–116	12	34–35	30		9⅝	17	
5 " 3 "	116–121	12½	35–36	30½		10	18	
5 " 4 "	121–127	13	36–37	31		10⅜	19	
5 " 5 "	127–133	13½	37–38	31½		10¾	20	
5 " 6 "	133–140	14	38–39	32		11⅛	21	
5 " 7 "	140–147	14½	39–40	32½		11½	22	
5 " 8 "	147–155	15	40–41	33		11⅞	23	
5 " 9 "	155–164	15½	41–42	33½		12¼	24	
5 " 10 "	164–174	16	42–43	34		12⅝	25	
5 " 11 "	174–185	16½	43–44	34½		13	26	
6 "	185–196	17	44–45	35		13⅜	27	

Furthermore a few explanatory words should be added as to the exact methods which have been agreed upon for making these measurements: 1. *Weight,* if possible, should be taken without clothes, but where this is impracticable the weight of the clothing should be learned, and subsequently deducted. 2. *Neck* girth should be taken by passing the tape around the neck just below "Adam's Apple." (See page 167.)

The chest should be measured by a tape embracing it so as to pass over the lower part of the shoulder blades, with the

arms held horizontally. Chest girth should be taken before and after inspiration.

Waist should be measured at the smallest part after a natural expiration.

Biceps can best be measured by bending the arm hard at the elbow and holding it horizontally away from the body, passing the tape around the greatest prominence on the arm.

Forearm is measured by the tape being passed around the largest part, the fist being firmly clenched and the palm of the hand turned upward.

Thigh. Stand with the feet about six inches apart, with the weight equally distributed on each leg, and measure the thigh just below the nates.

Calf. Stand as for measurement of thigh and take the measurement around the most prominent part of the calf.

Furthermore, in addition to the measurements already proposed, special attention should be called to the defects most frequently found from the disproportionate use of the various parts of the body; for instance, the head is drawn oftener forward than backward, and hence as a rule the head is held too far forward. For similar reasons the muscles of the right arm tend to pull that shoulder down, except in the case of left-handed people, when the reverse is true. Lack of use of the muscles of the back converts the shoulder-blades into "wings," and thin, narrow waists come from lack of use of the waist muscles, etc. Important as are these defects in the adult, they are still more so in the growing child, where they are more easily remediable than in the adult.

PHYSICAL DEFECTS COMMON IN CHILDREN AND ADULTS.

With children the most frequent of these defects, as noted by Dr. W. G. Anderson, are the following, concerning which it should be remembered that three months may possibly correct some, but that a year is oftener required to straighten round shoulders, and a longer time for a crooked spine. "*After fifteen or sixteen years of age it is a long and*

tedious task, and such as no one of that age will work at alone," says Dr. Anderson, after his wide experience in these matters, and hence the very great value of class work in the development of children.

(*a.*) *Head.*—Droops forward.
Carried on one side.
(*b.*) *Shoulders.*—Round, stooped, or sloping.
Right lower than left.
In left-handed people the reverse is generally seen.
The lower and inner border of the shoulder-blade is too prominent.
(*c.*) *Spine.*—Lateral curve of the spine between shoulders.
(*d.*) *Arms.*—The forearm larger in proportion than upper.
(*e.*) *Waist.*—Small, narrow, and weak.
(*f.*) *Hips.*—Thrown too far forward.
(*g.*) *Leg.*—Developed more than thigh.
(*h.*) *Thigh.*—Poorly developed on the back and inside.

The exercises which have been found most helpful for the correction of the common defects of children are given, especial pains having been taken to select those that can be performed without expensive apparatus.

(*a.*) *Head.*—To correct drooping, move the head backward and sideward, but not to the front. Roll the head from left to right backward, and throw the head to the rear as far as possible, keeping it level.

(*b.*) *Shoulders.*—To elevate a depressed shoulder, raise the arm, rigid, to the front or side. Draw the shoulder as high as possible. To draw the shoulders back, raise the arms to the front and force them back as far as possible, for any motion by which the hands come together back of the body is a good one. Place the hands on the hips, thumbs forward and fingers touching back, or clasp the hands back of the head and force the elbows back as far as possible. To return protuberant shoulder-blades to their places, any motion whereby the hands or arms are brought together behind the body is helpful, as are full swinging motions of the arms from front to rear.

(*c.*) *Spine.*—Any movement that will level the shoulders

will tend to cure lateral curvature and draw the shoulders to their proper position.

To depress a shoulder, any movement whereby the hand is drawn to the side forcibly or to the front or back of the body.

(*d.*) *Arms.*—To develop the front upper arm, any movement that will bring the hand to the shoulder or the shoulder to the hand.

To develop the back upper arm, any movement that will push the hand from the shoulder or the shoulder from the hand. To develop the front forearm, any movement drawing the palmar surface of the hand toward the elbow and clinching the hand.

The back forearm, opening the hand. Drawing the back of the hand toward the elbow.

To develop the chest, any movement where the hands are drawn to the front of the body.

(*e.*) *Waist.*—Front, any movement that bends the body forward.

Sides. Any movement that bends the body to one side will develop that side.

Back. Bending the body backward.

General rules: A rolling motion of the body on the hips. Twisting the shoulders to right or left.

(*f.*) *Hips.*—To draw the hips back, bend the body forward and backward. Raise each knee as high as possible. Raise each leg without bending the knee.

(*g.*) *Legs.*—Back. Any movement that raises the body on the toes.

Front. Any movement that raises the toes.

(*h.*) *Thigh.*—Front. Any movement that pushes the heels from the hips or the hips from the heels.

Back. Any movement that draws the hips to the heels or the heels to the hips.

Inside. Any movement that crosses the knees in front or behind.

(*i.*) *Ankles.*—The leg movements will strengthen the ankles.

Throw the ankles apart by bending feet to the side. Give a rotary motion to each foot when raised from the floor.

(*j.*) *Toes.*—To cure what is commonly called "pigeon toes," or "toeing in," keep the heel on the floor, and, raising the toes of the right foot, turn them forcibly to the right as far as possible.

(*k.*) *Chest.*—Cultivation of deep inspiration is exceedingly valuable in all cases of rickety or scrofulous children, or when there is any family history of consumption. Dr. Anderson recommends the use of the spirometer for this purpose. According to Hutchinson, the chief authority on the use of this instrument, persons should "blow" according to their height. It will be seen by glancing at the tables given that there is a difference of eight cubic inches for each inch in height.

A BOY.			A GIRL.		
In. height.		cu. in.	In. height.		cu. in.
48	should blow..............	70	48	should blow..............	32
49	" "	78	49	" "	40
50	" "	86	50	" "	48
51	" "	94	51	" "	56
52	" "	102	52	" "	64
53	" "	110	53	" "	72
54	" "	118	54	" "	80
55	" "	126	55	" "	88
56	" "	134	56	" "	96
57	" "	142	57	" "	104
58	" "	150	58	" "	112
59	" "	158	59	" "	120
60	" "	166	60	" "	128
61	" "	174	61	" "	136
62	" "	182	62	" "	144
63	" "	190	63	" "	152
64	" "	198	64	" "	160
65	" "	206	65	" "	168
66	" "	214	66	" "	176
67	" "	222	67	" "	184
68	" "	230	68	" "	192
69	" "	238	69	" "	200
70	" "	246	70	" "	208
71	" "	254	71	" "	216
72	" "	262	72	" "	224

Where a spirometer is not accessible excellent results may be obtained by the use of Julian Hawthorne's directions,

to inspire for seven steps and expire for the same time, or even, slow, deep inspirations and expirations (seven to eight per minute), through a quill or straw, are exceedingly valuable for the expansion of sunken chests. Such methods will slowly but surely broaden and deepen the chest of scrofulous, rickety, and consumptive children; and when conjoined with good plain diet—beef, eggs, and milk—and sensible clothing, will lengthen their days and build them up into the vigorous manhood and womanhood that it has been the aim of this book to inculcate as the duty and privilege of all tenants of the "House Beautiful."

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Dernière,